THE

Tea Research Institute

OF

Ceylon.

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BULLETIN No. 18

Annual Report for the Year 1937.

Published by

THE TEA RESEARCH INSTITUTE OF CEYLON,
ST. COOMBS, TALAWAKELLE.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. R. G. Coombe

(2) Mr. Jas. Forbes (Jnr.), (Chairman)

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Major J. W. Oldfield, M.C., C.M.G., O.B.E.

(5) Mr. I. L. Cameron (on leave) Mr. C. E. Hawes (acting).

(6) Mr. J. C. Kelly (on leave) Mr. K. W. Taylor (acting).

(C) Representing the Low-Country Products' Association :—

(7) Colonel T. G. W. Jayewardene, V.D.

(D) Representing the Small-Holders :—

(8) Mr. T. B. Panabokke

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary.

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

TWELFTH ANNUAL REPORT

OF THE

BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON

FOR 1937.

Foundation.—The Tea Research Institute of Ceylon was established by Ordinance No. 12 of 1925, dated the 27th October, 1925.

Past Chairmen of the Institute.

Name	Date of Appointment	Date of Resignation.
Major J. W. Oldfield, C.M.G., O.B.E., M.C.	7th January, 1926	24th November, 1926
Mr. John Horsfall	24th November, 1926	14th April, 1927
Mr. R. G. Coombe	14th April, 1927	9th April, 1929
Major J. W. Oldfield, C.M.G., O.B.E., M.C.	9th April 1929	30th September, 1929
Mr. C. Huntley-Wilkinson	30th September, 1929	28th November, 1929
Mr. R. G. Coombe	29th November, 1929	7th April, 1932
Mr. G. K. Stewart	7th April, 1932	26th November, 1932
Mr. R. G. Coombe	26th November, 1932	13th January, 1934
Mr. James Forbes, (Jnr.)	13th January, 1934	31st October, 1936
Mr. R. G. Coombe	31st October, 1936	2nd June, 1937
Mr. James Forbes (Jnr.)	2nd June, 1937.	

BOARD OF MANAGEMENT.

The constitution of the Board is laid down in the Ordinance; the personnel on the 1st January, 1937, was:—

Ex-Officio Members.

The Hon'ble the Financial Secretary (Hon. Mr. H. J. Huxham).

The Director of Agriculture (Mr. E. Rodrigo).

The Chairman, Planters' Association of Ceylon (Mr. R. P. Gaddum).

The Chairman, Ceylon Estates Proprietary Association (Mr. C. E. Hawes).

Representatives of the Planters' Association of Ceylon.

Mr. James Forbes, (Jnr.) (on leave) Mr. A. G. D. Bagot (acting).

Mr. R. G. Coombe.

Mr. J. D. Hoare.

Representatives of the Ceylon Estates Proprietary Association.

Major J. W. Oldfield, C.M.G., O.B.E., M.C.

Mr. I. L. Cameron.

Mr. D. T. Richards.

Representatives of the Low-Country Products Association.

Col. T. G. W. Jayewardene, V.D.

Representative of the Small-Holders.

Vacant.

Chairman.—Mr. James Forbes, (Jnr.) (on leave), Mr. R. G. Coombe (acting).

Secretary.—Dr. Roland V. Norris.

Solicitors.—Messrs. Julius & Creasy.

Auditors.—Messrs. Ford, Rhodes, Thornton & Co.

Registered Office.—The Victoria Commemoration Buildings, Kandy.

The Chairman, T. R. I.—Mr. James Forbes (Jnr.), resumed office as Chairman on his return from leave on the 2nd June, 1937, relieving Mr. R. G. Coombe who acted as Chairman during his absence.

Members of the Board.—Mr. Gordon Pyper was nominated by the Planters' Association of Ceylon to act for Mr. James Forbes (Jnr.), *vice* Mr. A. G. D. Bagot resigned, with effect from 25th February, 1937.

Mr. T. B. Panabokke was nominated by his His Excellency the Governor to represent the Small-Holders, *vice* Mr. D. H. Kotalawala resigned, with effect from the 2nd February, 1937.

Mr. I. L. Cameron was on leave from the 11th March to the 2nd December, 1937, during which period the Ceylon Estates Proprietary Association nominated Mr. W. H. Attfield to act for him.

Mr. F. A. Bond was nominated by the Ceylon Estates Proprietary Association to act for Mr. D. T. Richards who proceeded on leave from the 28th April, 1937. Mr. Bond resigned from the Board on the 6th December and was succeeded by Mr. J. C. Kelly.

Mr. R. A. Sharrocks acted as a representative of the Ceylon Estates Proprietary Association from the 13th May to the 26th November during the absence on leave of Major J. W. Oldfield.

Mr. C. E. Hawes on vacting the chair of the Ceylon Estates Proprietary Association on the 24th November, 1937, ceased to be an *Ex-officio* member of the Board and was succeeded by Mr. D. T. Richards.

MEETINGS OF THE BOARD.

Four meetings of the Board were held during the year, all in Colombo, the average attendance being eleven.

AUDITORS.

Messrs. Ford, Rhodes, Thornton & Co. continued to act as the Institute's Auditors.

COMMITTEES.

The following were the principal Committees in 1937 :—

Finance Committee.—The Chairman, T.R.I. the Chairman, Planters' Association of Ceylon, the Chairman, Ceylon Estates Proprietary Association, Major J. W. Oldfield, Mr. J. D. Hoare, Mr. J. C. Kelly (elected 23rd December, 1937) and the Director, T.R.I.

The Committee held four meetings.

Estate and Experimental Committee.—The Director, T. R. I. (Chairman), the Chairman, T.R.I., the Visiting Agent, the Superintendent, St. Coombs Estate, Messrs. R. G. Coombe, J. Horsfall, C. H. Wilkinson, D. T. Richards, R. H. Horne, J. T. Young and Dr. T. Eden (Convener).

Mr. F. J. Whitehead attended meetings of this Committee by invitation when manufacturing subjects were under discussion.

Mr. W. W. A. Phillips and Mr. L. C. A. Leefe acted for Mr. James Forbes (Jnr.), and Mr. R. H. Horne, respectively while these gentlemen were on leave.

At the end of the year Dr. Tubbs (Plant Physiologist) replaced Dr. Eden as convener of the Committee.

The Committee held four meetings during the year.

Medical Sub-Committee.—The Chairman, T.R.I., the Director, T.R.I. and Mr. G. D. Austin.

Mr. H. B. Sreerangachar was appointed to act for Mr. Austin while the latter was on sick leave at the end of the year.

JUNIOR STAFF PROVIDENT FUND.

Mr. J. D. Hoare vacated office as a Trustee of the Fund on the return of Mr. James Forbes (Jnr.), from furlough. During the year the rate of contribution to the Provident Fund, both by the Board and by Members, was increased to ten per cent. of salaries.

VISITING AGENT.

Mr. H. Tonks succeeded Mr. J. W. Ferguson as Visiting Agent in April, 1937.

ST. COOMBS ESTATE.

The weather was somewhat erratic during the year and generally adverse to quality. The crop obtained amounted to 172,226, lbs. against an estimate of 160,000 lbs. The teas sold in Colombo at an average of 82.02 cents gross or 77.30 cents nett.

The profit on estate working account amounted to Rs. 42,920 which is the highest figure realised since the Institute commenced work.

ESTATE SCHOOL.

The estate school was duly inspected by Government, and grant amounting to Rs. 413/- was received.

FINANCE.

The total receipts for the year amounted to Rs. 344,712 made up as follows: Cess Rs. 298,686; Profit on Estate Account Rs. 42,920/-; and Miscellaneous Receipts Rs. 3,106/-.

Expenditure on Revenue Account, including Depreciation at Rs. 38,619 and Interest Charges on the Government Loan at Rs. 44,588/-, amounted to Rs. 297,641/-. There was therefore a surplus on Revenue Account for the year of Rs. 47,071/-.

Capital Expenditure amounting to Rs. 76,795/- was incurred. This sum was made up of Rs. 46,484/-, Capital Expenditure on Assets, and Rs. 30,310/-, repayment of Government Loan.

The depreciation allocated for the year, Rs. 38,619/-, could therefore be met in cash only to the extent of Rs. 8,896/-.

Towards the end of the year the Board had under consideration the future rate of the cess which is at present 14 cents per 100 lbs. tea exported. In view of the fact that restriction is to be continued for a further period of five years it was unanimously decided to ask that the present rate of cess should be maintained until December 31st, 1943.

CONFERENCE.

The Fifth Conference of the Institute was held at St. Coombs on 22nd and 23rd January, 1937, and was very largely attended, nearly three hundred visitors being present on the first date.

PUBLICATIONS.

The Institute's publications are sent free of charge to Proprietors, Directors, Superintendents and Assistant Superintendents of all Ceylon Tea Estates of over 10 acres in extent and to London and Colombo Agency Firms dealing in tea, if they register their names with the Secretary.

Other persons can obtain the publications on payment of an annual subscription of Rs. 15/- per annum if resident in India or Ceylon and £1.5.0 if resident elsewhere.

Single numbers of *The Tea Quarterly* or Bulletins can be obtained at the rate of Rs. 2-50 or 4 shillings per copy.

The average distribution figure during 1937 amounted to 1,600 copies. This comprised 1,279 copies issued to Estate and Proprietary Interests, 96 issued to Libraries and Scientific Institutes, usually in exchange for other publications, and 224 copies to private subscribers.

Rs. 4,158/- was received by way of subscriptions and Rs. 3,350 from advertisements. As a result of these receipts there was a profit on publications for the year of Rs. 1,488/-.

The following publications were issued during 1937 :—

The Tea Quarterly, Vol. X, Parts I-IV.

Bulletin No. 15 — Investigations on the Planting, Pruning and Plucking of the Tea Bush by Dr. F. R. Tubbs.

Bulletin No. 16 — Selected Notes on the Manuring of Tea by Dr. T. Eden.

Bulletin No. 17 — Annual Report for 1936.

A combined index to the Institute's publications is now being prepared.

ACKNOWLEDGMENTS.

The thanks of the Institute are due to the Ceylon Chamber of Commerce, Colombo, for the use of their Board Room for meetings of the Institute held in Colombo.

Close co-operation has been maintained between the Institute, the Ceylon Estates Proprietary Association, the Ceylon Association in London, the Planters' Association of Ceylon and other bodies concerned in the tea industry.

The Audited Statement of Accounts and Balance Sheet for 1937 are included at the end of this Report.

ROLAND V. NORRIS,
Secretary.

REPORT

ON

ST. COOMBS ESTATE

FOR 1937.

Superintendent.—Mr. J. A. Rogers.

ACREAGE STATEMENT.

	A.	R.	P.
Tea in Bearing . .	264	1	06
New Clearings Tea 1937 ...	20	0	00
Tea Nurseries ...	1	1	08
Fuel Clearings ...	27	0	00
Reserve land available for planting	43	1	09
Building Sites ...	26	2	22
Waste, Swamps, etc. ...	32	1	14
Total Acreage ...	414	3	19

Climate.—Rainfall registered in 1937 — 85.42 inches, on 209 days.
Rainfal registered in 1936 — 92.82 inches, on 220 days.
The rainfall was low, and distribution poor.

Crop.—Total crop harvested in 1937—172,226 lbs.—Estimate 160,000 lbs.
Total crop harvested in 1936—154,235 lbs.—Estimate 150,000 lbs.
Increase in 1937— 17,991 lbs.

Yield per acre in 1937—652 lbs. on 264 acres.
Yield per acre in 1936—584 lbs. on 264 acres.

PRICES.

Colombo Sales.—The average for High Grown Teas sold on the Colombo Market in 1937 was 82 cents.

St. Coombs Prices.

Gross average in 1937 — 82.02 cents per lb.
Gross average in 1936 — 79.29 cents per lb.
Nett average in 1937 — 77.30 cents per lb.
Nett average in 1936 — 75.03 cents per lb.

Cost of Production.

1937 — 51.92 cents per lb. — Estimate 57.09 cents per lb.

1936 — 53.43 cents per lb. — Estimate 57.23 cents per lb.

Profit on Estate Working Account.

1937 — Rs. 42,920/- which is equivalent to Rs. 162/- per acre.

1936 — Rs. 32,910/- which is equivalent to Rs. 125/- per acre.

The Profit in 1937 is the highest made since the Institute started.

Cultivation—was carried out according to programme.

An increase of artificial manure is to be made in 1938 at the 3rd application.

Green Manures.—A thoroughly satisfactory green manuring programme is carried out, mainly with bush varieties, which are augmented by wild sunflower grown in ravines.

Owing to severe Eelworm attack on *Tephrosia vogelii*, this variety is to be substituted by *Crotalaria anagyroides*, which is so far thought to be immune.

Tea Nurseries.—Supplied 20,916 plants in 1937.

For the 1937 New Clearing	14,480,
For Poria Plots	6,175, and
For T.R.I. No. 12. Field Plots	261 plants.

The nurseries are to be thoroughly re-conditioned before re-planting.

New Clearings (Tea).—The 1931 Clearings A28 R2 P35 and 1932 Clearing A9 R2 P0 were taken into full bearing in 1937.

In 1937 — 20 acres of mana-grass land were opened up in tea. Of this acreage 18 acres were opened up in the orthodox manner, and 2 acres on the contour system, with plants 18 inches apart in the row, and contours 5 feet apart.

These clearings have been extremely well opened, though climatic conditions were far from favourable.

It has been decided to open up a further 16½ acres (approximately) in 1938, and a modified contour system is to be employed for the estate areas of this clearing, with plants 2 feet apart in the rows, and 4 feet between contours.

Swamps and Fuel Blocks.—8 acres of swamp land was opened up and planted with red gums in 1937.

The growth of gums previously planted is satisfactory, and these areas are gradually drying up.

Labour.—At the end of 1937 there were 379 working labourers on the Estate, which is equivalent to 1.43 labourers per acre in bearing. It is

essential, however, to maintain adequate labour on St. Coombs, as large demands on estate labour are made for Tea Research Institute requirements, etc., as is shown by the following figures for 1937.

Labour for Tea Research Institute work	8,116	labourers.
Lent Labour to T. R. I. Staff, etc.	2,715	,,
Labour used for 1937 Clearing	6,926	,,
Total	17,757	labourers.

This is equivalent to approximately 60 labourers daily, or, at an out-turn of 75 per cent., to about .30 labourer per acre.

As further land is to be opened up in 1938, additional labour will be taken on as required, when occasion arises, so that estate works shall not suffer.

Manufacture.—Manufacture and Rolling Room organisation have been handicapped by an insufficient number of rollers; this is, however, to be remedied early in 1938, as an additional roller is to be installed immediately. This will make it feasible to undertake any rolling programme likely to be required, without overloading rollers at any stage, and it will greatly assist in proper organisation in the rolling room.

Manufacture throughout takes place under thoroughly hygienic conditions.

The new 3 ft. Sirocco E.C.P. Drier (Short-tray) is working satisfactorily.

General.—The estate is in good order, and all cultivation and field works have been well carried out.

From 1937 the pruning cycles are being lengthened from 2½ to 3 years, (with the exception of No. 1. Field, 23 acres, which is pruned every 2 years).

This, with the thorough cultivation adopted, may be expected to result in increased yields, and in improved quality teas.

HUBERT TONKS.

Delmar Estate,
Halgranoya,
7th February, 1938.

REPORT

OF

THE DIRECTOR,

TEA RESEARCH INSTITUTE OF CEYLON

FOR 1937.

Administration.—No changes were made in the administrative arrangements brought into force in the previous year, and these continued to work smoothly.

Finance.—Exports of tea from Ceylon during the year were below the permissible quota. In consequence, the income derived from the cess, which remained at 14 cents per 100 lbs. of tea exported, fell short of the estimate, the actual income received from this source amounting to Rs. 298,686 against an estimate of Rs. 308,000 and receipts in 1936 of Rs. 305,282.

Receipts from St. Coombs Estate, on the other hand, were higher, Rs. 42,920 as against Rs. 32,910 in 1936. This was partly due to an increase in the nett sale price of St. Coombs teas, and partly to the increase in crop and consequential lower cost of production.

With miscellaneous receipts at Rs. 3,106, the total revenue for the year amounted to Rs. 344,712, the figure for the previous year being Rs. 338,351.

Expenditure on laboratory revenue account, excluding depreciation, amounted to Rs. 214,433 which was slightly below the estimate of Rs. 218,952. After making provision for depreciation of Rs. 38,619, and meeting interest charges on the Government Loan amounting to Rs. 44,588, the surplus on general revenue account for the year was Rs 47,072 as against Rs. 53,315 in 1936.

Capital expenditure was incurred amounting to Rs. 76,795 distributed as follows : Repayment of Government Loan Rs. 30,310 ; Land Developments

Rs. 13,476; Buildings and Lines Rs. 17,168; Furniture and Equipment Rs. 2,115; Laboratory Apparatus Rs. 1,334; Experimental Machinery Rs. 420; and Estate Machinery Rs. 11,980.

The depreciation written off during the year, Rs. 38,619, could therefore be met in cash only to the extent of Rs. 8,895. Liquid assets as at 31st December, 1937 amounted to Rs. 193,160. After deducting specific liabilities such as Rs. 10,834 accrued Interest on the Government Loan, Rs. 15,709 for Furlough and Passages Reserve; and miscellaneous credit balances amounting to Rs. 652, there remained cash amounting to Rs. 166,617 available against the liability under depreciation which at the same date amounted to Rs. 281,915.

St. Coombs Estate.—The Rainfall, 85.42 inches, was below average and the distribution was unfavourable to the production of quality teas. The crop obtained amounted to 172,226 lbs. against an estimate of 160,000 lbs. Prices were slightly more favourable than in the previous year, the average selling price in Colombo being 82.02 cents. The nett average was 77.30 cents against 75.03 cents realised in 1936. The cost of production was 51.92 cents and the profit on estate working account, Rs. 42,920, was the highest yet obtained on St. Coombs.

A further area of 20 acres was opened up in tea and it was found possible to reclaim and plant up with gums an additional 8 acres of the swamp areas.

In St. Coombs factory it was not found necessary after the numerous improvements and additions to plant carried out in 1936, to make any further extensive alterations. An additional roller, a C.C.C. single action machine with electrically-operated automatic pressure gear, was, however, ordered in December.

At the request of the Ceylon Fire Insurance Association, spark arrestor devices were fitted to the factory chimneys and tests of these will shortly be carried out.

Tests have also been in progress, on an experimental scale, of a new type of roller. This is referred to later in the report.

Conference.—The Fifth Conference of the Institute was held at St. Coombs on January 22nd and 23rd, 1937. On the first day the following papers were read, and discussed: (1) "Review of the Work of the Institute" by the Director; (2) "The Length of the Pruning Cycle" by Dr. F. R. Tubbs; (3) "The Treatment of Poria Root Disease of Tea" by Dr. C. H. Gadd; (4) "The Tortrix Problem" by Mr. C. B. Redman King; (5) "Research and the Practical Manufacture of Tea" by Mr. J. Lamb; (6) "Factory Organisation" by Mr. F. J. Whitehead; and (7) "Factory Hygiene" by the Director.

The first six papers together with the discussions were published in *The Tea Quarterly*. A reprint of the last paper was issued separately to Ceylon Tea Estates.

On the second day visitors had the opportunity of inspecting the Factory and Laboratories. Much interest was shewn in the demonstrations arranged in connection with Factory Hygiene.

The Conference was attended by some 280 visitors, amongst whom were the Director of the Proefstation West Java, Dr. Hoedt.

The demand for the conference number of *The Tea Quarterly* was so great that all copies were quickly exhausted.

Co-operation in Tea Research.—Close contact has been maintained with corresponding Research Institutes in India and the Netherlands East Indies. In addition to Dr. Hoedt's visit, referred to above, two other members of the Java Scientific Staff, Dr. Wellensiek, and Dr. Vollema visited St. Coombs, and Dr. Tubbs, the Plant Physiologist, paid visits to Tocklai and the U.P.A. S.I. Experimental Station in South India.

Staff.—No changes took place in the Senior Staff during the year. The Director was on home leave from the 17th February to the 10th September, during which period Dr. Gadd officiated as Director. Dr. Eden, Agricultural Chemist, returned from leave on the 7th August.

Advisory Work.—This continued to be heavy throughout the year. Some 2,700 enquiries were dealt with by correspondence, while, in addition, about 170 visitors, apart from those attending the conference and other meetings, visited St. Coombs, most of them to discuss specific problems with various members of the staff. Some 150 visits were paid to estates by members of the staff. The latter is a rather lower figure than in 1936, due to the fact that two members of the Senior Staff were on home leave during the year.

A feature of the enquiries is the increasing extent in which information is sought direct by Agency Houses and Visiting Agents. This is encouraging as indicating that the Institute is more and more having an influence on general estate policy.

As in previous years, several lectures were given to various District Planters' Associations. In addition, the Director attended the meetings of the General Committee of the Planters' Association of Ceylon, the Board of Agriculture, and occasional meetings of the Ceylon Estates Proprietary Association.

Close contact was maintained with the above Associations and also with the Ceylon Association in London. Lectures dealing with the work of the Institute were given to the latter body by the Director and Dr. Eden while on leave.

Publications.—There was a still further increase in the demand for the Institute's publications and the conference number of *The Tea Quarterly* was quickly exhausted. Altogether Rs. 4,158 was received in subscriptions for publications from those persons not entitled to a free issue. The average number of copies issued was 1,600.

In addition to *The Tea Quarterly*, the following Bulletins were issued during the year:—

No. 15.—"Investigations on the Planting, Pruning and Plucking of the Tea Bush" by Dr. F. R. Tubbs.

No. 16.—"Selected Notes on the Manuring of Tea" by Dr. T. Eden.

No. 17.—Annual Report of the Institute for 1936.

Mr. King was in charge of the Library during most of the year, and many additions were made by purchase or exchange.

Pests and Diseases.—In regard to insect pests, no new species have made their appearance during the year, and the position generally is on the whole more encouraging. In last year's report reference was made to a larval parasite of Tortrix which had been obtained from Java (*Macrocentrus* sp.). During the present year further trials have been made with this parasite and the results are very promising. It has established itself well on St. Coombs and neighbouring estates and also in other areas where trial liberations have been made. For technical reasons its general distribution will be a somewhat slow process, but further liberations will be made in September and October next which is the most favourable season in most areas. There is considerable reason to hope that this parasite may lead to a solution of the Tortrix problem. A short account of *Macrocentrus* was given in *The Tea Quarterly* 1937, Part IV, pp. 187-191.

An opportunity occurred during the year for a detailed examination of a Termite infested area, some 30,000 bushes on a Maskeliya estate being dug up and examined. The results of the examination, which were published in *The Tea Quarterly* 1937, Part IV. pp 195-206, suggest that *Neotermes militaris* is in all probability a less serious danger than is commonly supposed. Further details will be found in the report of the Entomologist.

Nettle Grub was once again not very prominent, except on a very small number of estates.

Considerable further work has been carried out on Shot-hole Borer to elucidate the life cycle and seasonal history of this beetle. Enquiries are being made both in America and in England in regard to the possibility of obtaining parasites or predators of *Zyloborus,* as biological control seems on the whole to be the only possible method of dealing with this pest.

In regard to fungus diseases, a disturbing event has been the occurrence of a new leaf disease of Grevilleas, vide *Tea Quarterly,* 1937, Vol. X, pp. 156-159, believed to be caused by a species of *Phyllosticta.* Some further details of this disease will be found in the report of the Mycologist. An interesting feature is the fact that what is believed to be the same disease appeared simultaneously in South India. So far, in Ceylon, the trouble has not reached high elevations and, though it is impossible to express a definite opinion on this point, it seems on the whole unlikely that up-country areas will be affected. In the low-country, however, the position is serious as there is no method of combating the disease which is economically feasible.

Further observations have been made on the disease known as *Phloem necrosis* which was referred to in last year's report. At present this disease is known to occur at high elevations only, and the best time for diagnosis is probably 4 or 5 months after pruning. No pathogenic organism has been found associated with the disease, nor has it as yet been found possible to transmit this to healthy plants by grafting or sap injections. The possibility of the cause being a deficiency of one of the minor elements required by plants has not been overlooked, but it will take some time before definite evidence on this point can be secured.

There is evidence that eelworm (*Heterodera marioni*) is becoming more prevalent up-country, and the advisability, therefore, of using a rotation of green manure crops has been stressed by the Mycologist. It has until recently been considered there was little risk to mature tea from eelworm. One case has, however, come to notice where such mature tea has been heavily attacked. Nurseries of course require particular care in regard to the prevention of eelworm infestation.

Agricultural Chemistry.—An interesting investigation in the Agricultural Division has been concerned with the decomposition of green manures. This is of considerable importance in view of the opinions that have been expressed that the direct incorporation of such material in the soil would lead to a locking up of available nitrogen and result in temporary nitrogen starvation. The Institute, on the other hand, considers that, provided the material has a suitable carbon-nitrogen ratio, and the materials in common use have in fact such a ratio, decomposition will proceed without removal of soil nitrogen. The experiments carried out support

this contention. They also throw further light on the nitrogen losses which may occur when material too rich in nitrogen is composted alone.

The manurial experiments concerning different quantities of nitrogen, phosphoric acid and potash have been continued both at St. Coombs and at the Sub-Station at Passara. The conclusions remain the same as before. Nitrogen applications give a progressive increase in yield; potash has had no influence on yield, but indications persist that omission of this nutrient for any considerable period has an adverse effect on quality; phosphoric acid has slightly increased yield, but no benefit has been derived by increasing the applications above 30 lbs. per acre.

The Institute is not infrequently asked to lay down a manurial programme designed to favour wood production while not encouraging crop. The impossibility of any such programme is clearly shewn by the figures quoted in Dr. Eden's report which indicate in a striking way the proportionality between wood and crop production.

Some preliminary figures are also quoted from the selective weeding plots. These figures are as yet purely provisional and the point of most interest at the moment is perhaps the indication that vigorous cultivation may have a depressing influence on yield.

Plant Physiology.—The pruning experiments which have been in progress in the Ratnapura area will be discontinued early in 1938. The main conclusions which have emerged were discussed by Dr. Tubbs in Bulletin No. 15 issued during the year under the title "Investigations on the Planting, Pruning and Plucking of the Tea Bush."

The general adoption in the low-country of methods of pruning designed to leave on the bush at pruning a sufficient amount of leaf to enable assimilation to continue, was immediately reflected in a marked decrease in the number of bushes submitted for diagnosis and reported as having died after pruning. In the past year there has been a certain increase in such specimens and in every case the history shewed that the bush had been clean pruned. It will be most regrettable if any return to clean pruning is encouraged at low elevations. This will inevitably lead to a renewal of mortality after pruning, owing to the carbohydrate deficiencies which occur at such elevations. The lung method of pruning was introduced specifically to meet this difficulty, and a very strong warning must be given against any tendency to revert to clean pruning under such conditions.

It is widely recognised that on an average estate the yield of any particular field is largely dependent on the leaf obtained from a relatively low percentage of the bushes and that quite a large proportion of the bushes contribute little towards the crop. That there is ample foundation for this

belief is strikingly shewn in the yield trial figures given by Dr. Tubbs in his report. The number of shoots plucked were recorded for five rounds, 1,515 bushes being used for the yield test.

The highest count obtained fell in the group 980-999, but this was from one bush only. More than two-thirds of the bushes gave figures below 200 and the numbers giving higher yields fell away rapidly, only 23 bushes in all exceeding the 400 figure.

There is no reason to think there is anything exceptional about these figures and it becomes at once obvious that even by a rough form of selection, marked improvement is possible. It is important to stress this because at the present time when much interest in replanting poor areas is being shewn, there is a risk that the planting material used may be little or no better than that being replaced. The Institute is actively engaged in selection work and has already under observation and test a considerable amount of selected material. Complete tests of such material, and the number of selctions for trial will of course increase to a very large figure, will naturally take some time. Meantime it is of the greatest importance that estates should themselves exercise a drastic selection in regard to the nursery supplies utilised for replanting. Only the most vigorous plants, and those which appear to conform to the type required, should be utilised, and though this will increase the initial cost, there is ample evidence from Java experience that this extra cost will be more than repaid.

In regard to seed supplies there is also need for a close scrutiny of Ceylon seed bearers. It is highly desirable that tests should be made of the progeny derived from individual seed bearers when it will probably be found that there is a far greater variation than is expected. From such a survey much could be done to improve seed supplies by the elimination of individual bearers found to be undesirable and the development of the better types.

Coupled with the question of selection, in which the fullest co-operation of estates with the Institute is necessary, is the problem of the propagation of selected material.

The Institute has been in close touch with Java and India in connexion with such work. It does not follow, however, that methods of propagation which suit conditions in one country will necessarily prove the best in other areas, where climatic and other conditions are entirely different. In fact direct experimental evidence already exists on this point. Budgrafting, for example, which has been very successful in Java is much more difficult to carry out in Ceylon. On the other hand very good results are being obtained at St. Coombs with single node cuttings from rested stems, and it is very probable that this will prove to be the most

useful method for Ceylon. In addition to the very much larger percentage of successful "takes" obtained here by this method, the material obtained is of course on its own roots and this is likely to be of further advantage, taking into consideration Ceylon methods of pruning.

Owing to the restrictions which have hitherto been imposed by the Tea Restriction Ordinance and the Ceylon Plant Pest Ordinance, selection has so far had to be confined to local material since export of tea seed or plant material from the various producing countries has been prohibited. It was realised of course that these regulations would unduly limit the Institute's search for improved material, and when the new Tea Restriction Ordinance was under consideration representations were made to London, asking that provision should be made for the exchange of small amounts of plant material and seed required by Scientific Institutes in Ceylon, Java, and India for their experimental investigations. These representations were successful. Under the Plant Pest Ordinance, however, the import of tea *seed* into Ceylon from India is still prohibited. This prohibition was originally imposed owing to the risk of introducing Blister Blight into Ceylon. It is considered, however, that little or no risk would be incurred from seed imported by the Institute which would of course be in small quantities and under the constant scrutiny of the Institute's technical staff. Representations will, therefore, be made for a modification of the regulations under the Plant Pest Ordinance so far as they relate to material required for *scientific investigations*. This application will not, however, cover, nor does the modification now introduced in the Tea Restriction Ordinance, the importation of seed on a commercial scale

Further details in regard to tea selection will be found in the report of the Plant Physiologist.

Soil Erosion.—In an endeavour to secure more rapidly information about different species of ground cover likely to be suitable for various areas, estates were asked to co-operate by reporting on locally occurring "weeds." Though the response has not been as great as was hoped for, a considerable number of species have been received and some notes on these will be found in Dr. Tubbs' report.

The Institute is co-operating with the Department of Agriculture in the compilation of a Manual of Weeds, which will contain coloured illustrations of the more useful species rendering their identification more easy.

Some anxiety was felt at one time in regard to the effect on soil erosion of the practice of denuding the soil of all litter and leaf-fall when the latter was collected for compost manufacture. The risks of this procedure which leaves the soil unduly exposed to wind, rain and sun, are now more fully realised and it seems likely that the practice will be discouraged.

Biochemistry and Manufacture.—Among the more interesting of the investigations in progress in the Biochemical Division was an enquiry into the mechanism of fermentation. Results of considerable value have been obtained, though these are perhaps in their present stage more of technical interest than of immediate practical application. Coupled with this enquiry investigations on the chemistry of tea leaf were in progress and here again interesting results are emerging.

In previous reports reference has been made more than once to the handicap under which experimental work on manufacture has to be carried out owing to the limited extent of our knowledge of the chemical nature of the constituents of green leaf and manufactured tea. It was suggested that this question might well form a subject for a joint investigation carried out in Europe and financed by the main tea-producing countries. This proposal has been supported by the Indian Tea Association and discussions are now taking place as to the best means of organising such work. Meantime the Board of the Institute has provisionally agreed to allocate a sum not exceeding Rs. 5,000 per annum for the purpose.

Considerable time has been spent during the past year in investigating the possibilities of a new form of tea roller devised by Mr. Clive Meares. While there have been some differences of opinion amongst brokers, particularly between Colombo and London, in regard to the merits of the type of tea produced, the results obtained undoubtedly justify further tests on a larger scale and arrangements are being made for this to be done. The preliminary work already carried out is referred to in some detail in Mr. Lamb's report.

Another subject to which reference must be made is the question of tea chest linings. The Institute was originally asked to take up this question in consequence of complaints regarding deterioration of tea in transit and storage. Much time and trouble was therefore spent in testing out under most stringent conditions various types of material for this purpose, the chief qualities required being strength and ability to withstand transport conditions without damage, impermeability to moisture and freedom from anything likely to cause taints. Amongst the large number of materials examined, the class which has to date shown most promise consists of paper coated with a very thin covering of aluminium. One particular variety of this class, known as Kraft Paper, has given particularly favourable results. Trial shipments have proved that the material has ample strength and is in this respect much superior to the usual metallic linings. It can readily and effectively be sealed and then keeps the tea in excellent condition. The Institute, on the basis of these tests which extended over a considerable period, felt fully justified in recommending the use of this material. Unfortunately events have shewn that buyers are opposed to this and similar

materials on the ground that they have no second-hand value, whereas, under present conditions particularly, metallic linings can readily be sold as scrap. No evidence has been brought to our notice of any other defect and one can only hope that further experience may convince those interested that on balance their use may be more advantageous than the present forms of lining employed which have obvious defects. It may be noted that a somewhat similar class of material is widely used in the packeting trade in England.

A considerable amount of time has also been expended on analytical work on tea carried out at the request of the Ceylon Association. The Institute has also actively concerned itself in the question of factory hygiene and has been in close touch with engineering firms interested in tea machinery, both in regard to improvement in design of plant to facilitate handling during manufacture, and also in regard to the actual materials used in constructing such plant. Engineering firms have shewn themselves to be keenly interested in such questions and it is a pleasure to acknowledge their co-operation.

Small-Holdings.—Throughout the year the Institute has continued to have two officers fully engaged on advisory work amongst small-holders in the Gampola and Baddegama areas. Considerable success has been achieved and many small-holders have shewn surprising keenness in improving their holdings under the advice of the Small-Holdings Officers. Competitions are held further to stimulate interest, and as evidence that the work is appreciated it may be noted that in the last competition in Uda Nuwara the whole of the funds required for prizes was contributed by Village Committees in the area.

Acknowledgments.—As in previous years our thanks are due to Messrs. Nayabedde Tea Co., Ltd., Messrs. George Steuart & Co., the Amalgamated Tea Estates Co., Ltd., the Anglo-American Direct Tea Trading Co., Messrs. James Finlay & Co., Ltd., the Scottish Tea and Lands Co. of Ceylon, Ltd., the Lunuwa (Ceylon) Tea & Rubber Estates, Ltd., and Messrs. Harrisons & Crosfield, Ltd., for facilities granted in connection with field experiments, and to the Superintendents of Gonakelle, Galatura, Wikiliya, Sarnia and Rookatenne Estates for their co-operation in such experiments. Numerous other Superintendents have also assisted us in various directions and for this and for kind hospitality extended to members of the staff grateful acknowledgment is due.

Agency Firms and Brokers, both in London and Colombo, have also generously assisted us in numerous ways, and particularly in connection with reports on experimental teas. We must acknowledge our indebtedness to Messrs. Wilson, Smithett & Co., Messrs. George White & Co., and Messrs. Thomson, Alston & Co., Ltd. in London, and to the following Colombo Firms: Messrs. Forbes & Walker, Messrs. Harrisons & Crosfield,

Ltd., Messrs. Whittall & Co., Messrs. the Colombo Commercial Co., Ltd. Messrs. Carson & Co., Ltd., Messrs. Brooke Bond (Ceylon) Ltd., Messrs. Heath & Co., Messrs. Lipton Ltd., Messrs. Somerville & Co., Messrs. George Steuart & Co., Messrs. Mackwoods Ltd., Messrs. Lee, Hedges & Co., Ltd., Messrs. Leechman & Co. and Messrs. E. John & Co.

Mr. R. H. Horne and, during his absence on leave, Mr. L. C. A. Leefe kindly acted as convener of the tasting team in Colombo, while Mr. E. Loudon-Shand has acted in a similar capacity in London.

The co-operation of Engineering Firms has already been referred to and we are particularly indebted to Mr. F. J. Whitehead who has freely placed his exceptional experience at our disposal. Mr. H. Tonks, the Visiting Agent, has similarly accorded valuable guidance and assistance in estate matters.

The Reports of the Scientific Staff are appended.

ROLAND V. NORRIS,

Director.

REPORT

OF

THE MYCOLOGIST

FOR 1937.

Staff.—During the Director's absence on leave from February 17th to September 10th, 1937, the Mycologist carried out duties as Acting Director, and from November 6th to December 4th, 1937, during the absence of the Plant Physiologist in India he took over part of the work of the Physiological division in addition to his own duties.

Advisory.—488 letters were received and 431 despatched during the year. The corresponding figures for 1936 were 533 and 464 respectively. The number of consignments of diseased plants received for examination, however, showed a marked increase, being 294 in 1937 as compared with 195 for 1936. The increase in the number of diseased specimens submitted for examination and report is not indicative of an increase in the incidence of disease generally in tea, but is rather the result of growing interest in various pathological conditions of the bush not generally understood. This perhaps is a natural consequence of the somewhat improved economic conditions.

Of the 294 consignments 237 were tea; the remainder consisted of Albizzia, Bead tree, Crotalaria, Dadap, Gliricidia, Grevillea, Gum, Solanum and Tephrosia.

22 visits to estates were made for investigational and advisory purposes in the Agrapatana, Badulla, Bandarawela, Galaha, Galle, Gampola, Hewaheta, Kandapola, Madulkelle, Matale and Ratnapura districts. A number of small-holdings in the Galle district were also inspected.

Poria.—A paper dealing with the treatment of this disease, based on observations made during field treatment on St. Coombs, was read before the Fifth Conference at St. Coombs and was published in *The Tea Quarterly*, Vol. X, pp. 36-45. Work has been continued in the disease plots but there is little to add to the conclusions given in the above mentioned paper.

During the year 13 new patches were located bringing the total observation to 128. From the new patches 17 obviously diseased and 63 infected bushes, which appeared perfectly healthy as viewed above ground, were removed. The ratio of dying to apparently healthy though infected bushes was therefore 1 :3.7, which is considerably higher than that (2.6) obtained in 1936. No importance is attached to the exact value of this ratio except in so far that it indicates roughly the number of apparently normally healthy yet often severely infected bushes likely to be found in the immediate vicinity of obvious sickly bushes attacked by this disease. That there are far more diseased bushes than is at first apparent in any Poria patch must be borne in mind during any attempt to eradicate the disease. The removal of dead and sickly looking bushes only can never effect eradication, as past experience has shown.

The first step in the treatment of a Poria patch is to deep fork through the area to ensure that no infected roots have been left in the soil. It is extremely rare to find such areas free of infected tea roots. Often, the whole root systems of dead bushes can be located. The removal of all such diseased roots is essential before tea can be established there again. The failure to establish tea on old Poria sites, in practically every case investigated, has been due more to the presence of old roots in the soil than to the presence of the disease in an active form on the perimeter of the patch. In other words the death of supplies within the patch follows infection from roots of bushes which have been incompletely removed rather than reinvasion of the area by the fungus living on the roots of bushes on the perimeter of the patch. This suggests that where the 'piecemeal' method of treatment of diseased bushes on the perimeter is adopted, it may be possible to replant the main area with tea before the treatment of the perimeter can be considered to be complete. Such early replanting may be of importance where the bare areas are large.

To determine the practicability of this suggestion all Poria patches on St. Coombs have this year been supplied (N. E. planting) with tea, no matter whether the treatment of the perimeter was considered complete or not. All such areas had previously been cleared of diseased roots and *Tephrosia vogelli* had been grown on the majority for at least twelve months. This plant has proved very useful as an indicator of diseased roots overlooked in the cleaning process. Where such plants have died on Poria patches the tea root, often a small piece, which lead to infection has invariably been found.

Rosellinia.—Further cases have been observed during the year in which this disease has spread through the surface litter of fallen leaves and attacked tea bushes at the collar. The spread of this disease is far more rapid and extensive when the fungus can proceed in this way than when limited to below-ground infections from root to root. On estates where

this disease occurs, precautions should be taken against its dissemination through litter by keeping the fallen leaves raked back from the collar, particularly in the vicinity of known infected areas.

Starch Deficiency.—Following the general adoption in the low-country of methods of pruning, particularly that known as "rim-lung," which leaves on the bush after pruning a fair amount of leaf to carry on the work of starch formation, there was a marked decrease in the number of bushes submitted for diagnosis which had died after pruning. This year there has been an increase in the number of such bushes sent for examination, and in all cases the bushes had been clean pruned. If a method of pruning is to be regarded merely as a temporary fashion, it should be borne in mind that the tea bush will not alter its food requirements after pruning to meet the whims of a 'fashionable' pruner. The clean pruning of a tea bush which is deficient of starch reserves can only result in dieback or death, according to the extent of the deficiency. If losses from such deficiency are to be prevented, the method of pruning must be such that sufficient leaves remain on the bush after pruning to manufacture the necessary elaborated foods. The 'rim-lung' method of pruning was introduced, not to create a change of method purely for a change, but to meet this basic requirement of the tea bush.

Phloem Necrosis.—A short account of this disease was published in the Annual Report for 1936; a few further details can be added to what was published there. The name *Phloem necrosis* was applied to this disease owing to the presence, at least in advanced stages, of dead areas within the inner cortex usually very close to the cambium of the roots. Necrosis has also been found in the stem cortex and also in the petiole, midrib and veins of the leaf, particularly when the leaf is of the curly type. There appears to be no definite relationship between the amounts of necrosis found in the different organs. As a rule when the markedly curled leaf occurs there is a large amount of necrosis in the root, which is demonstrable to the naked eye, but this is not always the case. Recently, specimens have been examined which had a pronounced leaf curl and a marked necrosis in the veins yet no necrosis was visible in the root tissues. On the other hand necrosis may be pronounced in the root cortex yet none may be found in the leaf veins.

The absence of easily demonstrable symptoms makes the identification of this disease extremely difficult for estate managers. Obviously, all non-productive bushes with low jât leaf characters are not all affected by disease, nor by this disease in particular. Only the presence of necrotic areas in the root stem or leaf affords positive evidence of this disease. This means that at present the disease can only be diagnosed with certainty when the condition has reached a relatively advanced state. The earliest symptoms of the disease are still unknown.

On those estates where the disease is known to occur, Estate Superintendents have little difficulty in recognising advanced cases at any time in the pruning cycle. The best time for diagnosis is probably 4 or 5 months after pruning. Affected bushes then show very little growth, and that usually abnormal, while the more healthy bushes have reached the tipping stage. It must be borne in mind that this disease is at present known to occur only at high elevations where shortage of food reserves is never a cause of delayed recovery from pruning. No specimen affected by this disease has yet been found to be deficient of starch reserves. Delayed recovery from pruning in the *Phloem necrosis* area is usually associated with this disease. Such bushes so far examined have always exhibited a marked necrosis throughout the root system. Delayed recovery from pruning in the low-country must not be regarded as a sympton of this disease.

It appears that the operation of pruning accelerates the development of diagnostic symptoms. I am indebted to an Estate Superintendent for the experimental data on which this statement is founded. Bushes which could be diagnosed definitely as affected by *Phloem necrosis* were removed from an area before pruning, yet after pruning and about tipping time, others could then be recognised. Such bushes were no doubt affected before pruning but had not reached a stage at which they could be recognised with certainty without a root examination.

Continued search has been made for a pathogenic organism within the diseased plants without success.

Attempts have been made to transmit the disease to healthy plants in different ways, including different forms of grafting and injection of sap extracted from diseased specimens. A satisfactory union between the healthy plant and diseased scion has on no occasion been obtained and all experimental plants remain to all appearances perfectly healthy. Approach grafting probably affords the best chance of obtaining satisfactory union and efforts will be made along that line in future work.

A few diseased bushes have been successfully transplanted on St. Coombs. Attempts were made to obtain root fusions between healthy and diseased bushes. As was to be expected a number of the transplanted bushes failed to survive. The others are alive but are not growing satisfactorily. They are too sickly to attempt any excavations to ascertain whether root fusion has occurred. The bushes to which they are attached appear to remain healthy.

These transplanted bushes will, however, afford useful information independent of any root fusion which may or may not occur. The bushes have been removed into entirely different surroundings both as regards soil and climate. If either or both of these are primary factors in the causation

of the disease, it is to be expected that in the course of time, if the bushes survive, they will throw off the symptoms of disease and produce normal growth as a result of their new conditions. At present there is no indications of the bushes throwing off the symptoms of disease. The new growth which has so far occurred is of the same type as that observed before transplanting. It is however yet too early to draw any conclusions regarding the result of removing the diseased bushes into different surroundings.

Stem Cankers.—Very little is known about the causative organism of some of the cankers occasionally occurring on tea branches. Usually, the cankers have reached a very advanced stage before they are observed. One, new to the writer, was observed this year on young tea supplies grown as seed-at-stake. The plants had made very good progress and the first indication that anything was amiss was the progressive death of the above ground parts somewhat suggestive of a rapid dieback. The real seat of the trouble was located just above ground level where a canker had developed and ultimately had encircled the stem. The effect of the canker was much the same as though the stem had been ring barked. The identity of the causative fungus could not however be determined.

Sooty Mould.—During November and December an abnormally large number of specimens of and enquiries regarding Sooty mould, which had become very prevalent on tea in certain districts, were received. Sooty moulds occur on a large variety of trees as a black membranous coating over the leaves and fruit. The membrane however is entirely superficial and usually may be easily rubbed off. With age, particularly under dry conditions, it may become detached and blown off in fragments by the wind

The fungi which form the black membranes extract no nutriment from the leaves or fruits on which they occur, but live on the sugary secretions (honey dew) formed by certain insects, usually scale insects and aphids. The amount of Sooty mould occurring at any time is dependent upon the amount of honey dew and consequently upon the number of insects present. If the honey dew secretion is slight in amount the Sooty mould occurs as spots, but usually distinct sheets are formed on leaves before it attracts attention.

The insects usually occur on the undersides of the leaves, and as the secreted honey dew falls on to the upper surface of lower leaves the Sooty mould occurs in that position. On tea the mould occurs principally, if not entirely, on the upper surface of the older leaves and very rarely, if ever, is it found on the flush. The insects which secrete the honey dew often are not living in the tea bush itself but on an overhanging shade tree. This is particularly the case when Gliricidias are intergrown with tea, but other shade trees also harbour the insects.

Any remedial measures considered necessary should be directed against the insects which secrete the honey dew; and for this purpose an insecticidal spray such as kerosene emulsion is necessary. It is very doubtful whether such treatment is ever necessary with tea. The bushes may look very unsightly and give the impression that they are seriously diseased but they suffer little serious harm unless infested by the insects. The Sooty mould will persist for a long time after the insects have disappeared, in fact until it becomes detached and blown off in fragments. Any decision regarding the necessity for spraying should be based upon the presence, position and numbers of the honey dew secreting insects.

These insects are normally controlled by weather conditions, as they usually disappear during wet weather. The unusual abundance of Sooty mould this year is attributable to the failure of the north-east rains, which have been unusually light, to eliminate the insects which secrete the honey dew on which this mould lives.

As already stated, Sooty mould does not penetrate the leaf nor extract nutriment from it. The only direct harm it can do to the bush is by preventing a certain amount of light from reaching the leaf surface and so reducing the rate of formation of sugars and starch within the leaf. That, if of serious importance, would somewhat retard the rate of growth of the bush and consequently affect the crop. This however does not occur to any appreciable extent in tea. Where the insects occur within the tea bush itself their adverse effect on the bush is considerably greater than that resulting directly from the presence of the fungus. Sooty mould, itself unsightly, is a reliable indicator of a less conspicuous but more harmful pest.

Eelworm.—The root knot eelworm (*Heterodera marioni*) has become during the last few years far more prevalent in up-country tea soils, especially where *Tephrosia vogelii* has been grown continuously for green manure. Attention has been called to this fact in an address given to the Nuwara Eliya Planters' Association (published in *The Tea Quarterly*) in which the value of rotation of green manures was indicated. Though adult tea is very resistant to this pest, tea seedlings are very susceptible. Where this eelworm has become very prevalent in the fields care should be taken to prevent its entry into the nurseries.

Leaf-Fall of Grevillea.—The most important event of pathological importance this year has been the occurrence of a new leaf disease of Grevilleas in the low-country, an account of which was published in *The Tea Quarterly*. (Vol. X, pp. 156-159). The disease has persisted throughout the year on the majority of estates and has been active in causing leaf-fall principally after rains. One observer in the Pelmadulla district states that "one of the worst types of weather for this disease is evening rain and heavy mist

in the morning." An estate in the dry zone on which the disease occurred during the early months of the year reported its disappearance when the weather became dry and its reappearance at the beginning of December, with the rains.

In addition to the districts previously named in *The Tea Quarterly* the disease has been reported from the Kalutara district and from one estate in the Nawalapitiya area. This last record is of importance as the disease occurred there at the beginning of September at an elevation of 2,000 feet which is the highest altitude at which the disease has yet appeared in Ceylon. It then occurred only on young trees which were growing near to rubber. Except for this isolated instance the disease has not passed on to new areas since its initial outbreak. The disease is at present restricted to what may generally be described as rubber areas though it has not occurred in all rubber districts.

Fears have been expressed regarding its invasion up-country. It may be unwise to volunteer a prophecy concerning a disease of this nature, but it may be stated that the evidence so far available indicates an unlikelihood that such invasion will occur. It may be remembered that when the oidium leaf disease of rubber first occurred in Ceylon in 1925, it spread rapidly through certain areas. Since that time its distribution has not materially altered. The rapid spread of the Grevillea leaf-fall disease resembled that which occurred with oidium. It is to be expected that climatic conditions will prove a limiting factor of the distribution of this disease just as they have proved to be for oidium.

Associated with this disease is a fungus, a species of *Phyllosticta*. All leaves falling during an attack of this disease bear irregular (both in size and shape) dark coloured spots which later become grey. This discoloured, diseased area may cover the whole or greater part of very young leaves recently emerged from the bud. Inoculation experiments have proved that these spots are caused by the *Phyllosticta*, but proof is not yet conclusive that the same fungus also causes the leaf-fall. The fact that falling immature leaves invariably bear these lesions is suggestive that both symptoms have a common origin. Inoculation experiments on cut shoots supply confirmatory evidence.

A short description of the *Phyllosticta* is as follows :—

Pycnidia dark brown, scattered, mainly epiphyllous, globose sometimes flask shaped, erumpant becoming almost free, 116-174 μ in diameter; ostiole usually lighter in colour, depressed in globose specimens, 14.5-17.4 μ diameter. Spores oblong with obtuse ends, hyaline, non-septate, biguttulate $3.9-6 \times 1.8-3$ μ extruded as tendrils.

On germination the spore swells to two or three times its original size and by a process of budding, sometimes by cell division forms a row of rounded cells somewhat resembling a short row of beads. Later, germ tubes develop from some or all of these cells, and a normal septate mycelium is developed. Similar bodies consisting of a few rounded cells occur attached to the hairs of diseased Grevillea leaves and culture experiments have demonstrated that they give rise to cultures of this species of *Phyllosticta*. It seems possible, though proof of this has not been attained, that the fungus in this condition may survive periods adverse to growth.

Cercosporella Theae.—Specimens of *Crotalaria usaramoensis* and of *Tephrosia vogelii* affected by collar rot were received from up-country estates in April and August respectively. These plants had been attacked by *Cercosporella theae* at ground level and the whole of the plants above the attacked area had died in consequence. Inoculation experiments in the laboratory with this fungus failed to cause infection of well-grown Crotalaria plants at the collar, though positive results were obtained when inoculations were made higher up the stem.

Cercosporella theae is best known as a leaf disease of tea which occurs in an epidemic form in certain years during the South-West Monsoon. The disease has long been known to occur on Acacia and Eucalyptus and such trees have been regarded as the main source of infection of tea when climatic conditions are favourable. The discovery of the fungus on other plants such as Crotalaria, *Tephrosia vogelii* and *Tephrosia radicans* (reported in the last annual report) associated with disease symptoms at ground level and at times when the disease is not flourishing in more aerial parts of plants is suggestive that the host range of this fungus is much wider than has been suspected.

The occurrence of this disease on Crotalaria and *Tephrosia vogelii* is probably not of great economic importance. It is most likely to occur under conditions, such as overcrowding, which tend to maintain a high humidity at the surface of the ground. In years when atmospheric conditions favour the occurrence of the disease in a somewhat severe form in tea these green manure bush plants are likely to be affected at the same time.

C. H. GADD,

Mycologist.

REPORT

OF

THE ENTOMOLOGIST

FOR 1937.

Staff.—There were no changes of Staff in 1937. The Assistant Entomologist was granted three months' sick leave out of Ceylon, and left for England on November 10th.

Correspondence.—682 letters were received and 784 despatched during the year. 163 specimens were received for report.

Tortrix.—Tortrix was little in evidence during the year, but appeared in isolated patches in various places. It may almost be said to be a minor pest at the present time. Certainly during the past ten years there has been a continuous decline in its abundance Whether there is a long cycle of decline and increase, there is insufficient evidence to say, but judging from past records it is probable that at some time or other it will again increase considerably over its present population.

The last remark is subject to modification on account of a significant (at present) change in its environment. The introduction of the Long-tailed Parasite from Java in 1935 seems to have been successful in that the parasite has found local conditions to its liking, and its development and spread at the expense of Tortrix has so far demonstrated its suitability for the purpose of checking the pest. At the end of 1937 its range was probably not less than 1,000 acres, including the whole of St. Coombs and at least two estates bordering it. In September, Tortrix was reported fairly common from the central part of the Maskeliya valley and after an examination of several estates liberations were made on two estates where a healthy Tortrix attack was in progress. Further liberations were also made on Diyagama and Edinburgh estates, where there were attractive Tortrix populations.

It is important to remember that the parasite attacks the caterpillar stage only, so that reports of Tortrix attacks which refer only to large numbers of egg masses have no value as regards the liberation of parasites is concerned; and there may or may not be a Tortrix attack to follow.

Since the seasonal increase of Tortrix lies between July and January, the best time for liberation is September to October since the parasite has an increasing population to work on. For the present, therefore, until more is known about its capabilities, releases in new areas will not be made between January and August.

The status of the parasite with regard to Tortrix at present is very high, and easily outclasses all local parasites put together. Time may modify its present quality, but up to the present no predators or hyper-parasites of any importance have been found. Of the latter, four species have been found, three of which are only occasionally hyper-parasitic, as they have been found also as primary parasites of Tortrix. The fourth is a true hyper-parasite, found in Java as well as Ceylon. So far, its appearance in *Macrocentrus* has been very rare.

Termites.—During the year a thorough investigation of the position of *Neotermes militaris* as a pest of tea at high levels was undertaken. Nearly 30,000 bushes were dug up in Maskeliya in a termite-infested locality, and examined with regard to damage and occupation. It was found that 17 per cent of the bushes had been attacked during a period of 50 years, and rather less than 5 per cent contained living termites. It was concluded that the damage inflicted was very small, and that, far from destroying the bushes, termites abandon them after an occupation of several years (say 15-20) leaving the bushes little the worse. The rate of spread, which is entirely subterranean, from root to root, is very slow. If rejuvenation is considered in such areas by entire removal and replanting, it is only necessary to see that all roots are taken out, so that no termites are left in the ground, and a ditch dug round to isolate the neighbouring area.

An extended report of this work was published in *The Tea Quarterly*, Vol. X, Part 4.

With regard to termites in bungalows and factories, several visits were made to report on the damage done and to make recommendations for control.

Nettle Grubs.—Only 16 estates reported attacks in 1937, the average acreage per month being 411, compared with 475 in 1936 and 384 in 1935. The contra-measures carried out consisted of the collection of grubs and cocoons, and in the case of bad attacks, spraying with soap and water.

The commonest species was *Natada nararia*, but Poonagalla reported a severe outbreak of *Parasa lepida* ("Blue-striped" Nettle Grub) in November.

The only parasites seen were *Fornicia Ceylonica* and *Rhogas* sp., particularly in July and August. The former were hyper-parasitised to the extent of 25 per cent by *Calliceras* sp.

Table I gives a summary of the Nettle Grub returns for the year, and Table II gives the distribution. Table III gives comparative figures from 1931 inclusive to date.

TABLE I.

NETTLE GRUB RETURNS, 1937.

Planting District		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
BADULLA DISTRICT 46 estates supplied with post cards. Total acreage under tea=31,686.	No. of estates which sent in returns	18	19	20	21	25	24	22	23	19	20	21	18
	,, ,, ,, declared free of pest	17	18	19	20	22	18	17	20	18	19	19	16
	,, ,, ,, reported outbreaks	1	1	1	1	3	6	5	3	1	1	2	2
	Total acreage affected	210	117	269	90	253	286	497	122	83	46	47	91
PASSARA DISTRICT 9 estates supplied with post cards. Total acreage under tea=9,447.	No. of estates which sent in returns	9	8	8	7	7	8	8	7	9	8	7	7
	,, ,, ,, declared free of post	8	6	6	4	3	3	5	4	7	6	6	6
	,, ,, ,, reported outbreaks	1	2	2	3	4	5	3	3	2	2	1	1
	Total acreage affected	145	170	250	210	368	283	360	323	88	241	123	98
MADULSIMA DISTRICT (Including Lunugala) 14 estates supplied with post cards. Total acreage under tea=10,654.	No. of estates which sent in returns	9	9	9	9	9	8	9	8	9	9	9	9
	,, ,, ,, declared free of pest	9	9	9	8	9	8	9	7	9	8	9	9
	,, ,, ,, reported outbreaks	—	—	—	1	—	—	—	1	—	1	—	—
	Total acreage affected	—	—	—	1	—	—	—	12	—	8	—	—
HAPUTALE DISTRICT (Including West Haputale) 42 estates supplied with post cards. Total acreage under tea=22,065.	No. of estates which sent in returns	16	16	15	22	21	22	20	14	12	14	14	15
	,, ,, ,, declared free of pest	14	16	14	20	19	21	19	14	11	14	12	15
	,, ,, ,, reported outbreaks	2	—	1	2	2	1	1	—	1	—	2	—
	Total acreage affected	16	—	15	1	23	15	1	—	10	—	40	—
UVA (Above Districts only) 111 estates supplied with post cards. Total acreage under tea—73,852.	No. of estates which sent in returns	52	52	52	59	62	62	59	52	49	51	51	49
	,, ,, ,, declared free of pest	48	49	48	52	53	50	50	45	45	47	46	46
	,, ,, ,, reported outbreaks	4	3	4	7	9	12	9	7	4	4	5	3
	Total acreage affected	371	287	534	317	644	584	858	457	181	295	210	189
	Percentage (acreage) infection per month	0·50	0·39	0·72	0·43	0·87	0·79	1·16	0·62	0·25	0·40	0·28	0·26

TABLE II.

SUMMARY OF NETTLE GRUB OUTBREAKS IN UVA DURING 1937.

1937	Badulla District*			Passara District			Other Districts**			Whole of Uva			
	Estates affected	Out-breaks	Acreage attacked	Estates affected	Out-breaks	Acreage attacked	Estates affected	Out-breaks	Acreage attacked	Estates affected	Out-breaks	Acreage affected	% Acreage affected
January	1	4	210	1	2	145	2	2	16	4	8	371	0·50
February	1	4	117	2	3	170	—	—	—	3	7	287	0·39
March	1	4	269	2	5	250	1	1	15	4	10	534	0·72
April	1	3	90	3	5	210	3	3	17	7	11	317	0 43
May	3	7	253	4	8	368	2	2	23	9	17	644	0·87
June	6	6	286	5	10	283	1	1	15	12	17	584	0·79
July	5	8	497	3	6	360	1	1	1	9	15	858	1·16
August	3	3	122	3	5	323	1	1	12	7	9	457	0·62
September	1	2	83	2	5	88	1	1	10	4	8	181	0·25
October	1	2	46	2	5	241	1	1	8	4	8	295	0·40
November	2	2	47	1	2	123	2	2	40	5	6	210	0·28
December	2	2	91	1	1	98	—	—	—	3	3	189	0·26

* Includes Namunukula

** Includes Haputale, Madulsima and Lunugala Districts.

TABLE III.—NETTLE GRUBS IN UVA, 1931—1937.

Planting District		1931	1932	1933	1934	1935	1936	1937
Badulla	Average No. of outbreaks per month	7.5	5.3	6.6	5.0	3.5	4.0	3.9
	Average acreage affected per month	373	439	333	217	143	236	176
	Percentage (acreage) infection per month	1.14	1.33	1.00	0.65	0.43	0.71	0.53
Passara	Average No. of outbreaks per month	7	4	4.5	7.5	9	4.4	4.8
	Average acreage affected per month	727	390	250	251	229	210	222
	Percentage (acreage) infection per month	7.42	3.98	2.54	2.55	2.32	2.13	2.30
Haputale and Haputale West	Average No. of outbreaks per month	2	1	0.5	0.2	0.25	0.5	1
	Average acreage affected per month	180	46	22	0.2	.75	6	11
	Percentage (acreage) infection per month	0.74	0.18	0.09	—	0.29	0.02	0.04
Madulsima and Lunugala	Average No. of outbreaks per month	2	0.2	1	0.5	0.5	0.58	0.25
	Average acreage affected per month	101	1	43	5	5	24	2
	Percentage (acreage) infection per month	1.01	0.01	0.43	0.05	0.05	0.24	0.02
Uva	Average No. of outbreaks per month	18.5	10.7	12.5	13	10	9.5	9.9
	Average acreage affected per month	1381	876	648	773	384	475	411
	Percentage (acreage) infection per month	1.77	1.12	0.81	0.98	0.49	0.60	0.52

A new Nettle Grub, *Oxyplax ochracea*, appeared on tea in February. It is not likely to become a pest, and is more of a curiosity. Its life history was worked out as follows :—

Stage		Duration	Approximate average temperature
Egg	...	9 days	73°F.
Larva (Male)	...	80 ,,	76°F.
(Female)	...	97 ,,	
Pupa (Male)	...	27 ,,	78°F.
(Female)	...	26 ,,	...

The total cycle, at about 76°F., is :—

Male	...	115 days
Female	...	131 ,,

The above figures relate to tea as the food plant. When fed on Dadap, the larval period is appreciably shorter :—

Stage		Duration	Approximate average temperature
Egg	...	9 days	73°F.
Larva (Male)	...	72 ,,	
(Female)	...	73 ,,	76°F.
Pupa (Male)	...	27 ,,	78°F.
(Female	...	26 ,,	78°F.

the cycle being :—

Male	...	112 days
Female	..	108 ,,

Shot-Hole Borer.—Further work has been carried out on the behaviour of this beetle with regard to tea. Thousands of branches have been examined to elucidate both the life-cycle, life-history and seasonal history of the beetle. There is as yet insufficient to provide a complete answer to this.

Since the principal damage caused by shot-hole borer is mechanical, a good deal of time has been devoted to an investigation of the different types of galleries made in relation to the size of the stem. Some types are much weaker than others. 38 types have been drawn, and it is probable that these can be grouped together in a smaller number of main categories. Only a certain proportion of these types is weak enough to allow the stem to be snapped easily. In these cases, if growth takes place sufficiently rapidly, the critical period of snapping is passed. Experiments are now being started with a view to assessing this rapidity of growth in relation to different kinds of manuring.

Although there is a long list of plants recorded as alternative hosts to the shot-hole borer of tea, there is considerable doubt about many of these being valid. Investigations were therefore started to verify these or otherwise.

Red Borer. (*Zeuzera coffeæ*).—This caterpillar borer, which mines the stems of tea, was reported from several different places during the year. The bores reach a diameter of about a quarter-of-an-inch. An occasional hole is made in the side of the stem through which the saw-dust like grass

is exuded, and this betrays the presence of the caterpillar within. Such stems may be cut below the gallery and burned. Although not uncommon, their numbers are far too few for them to constitute anything but a very minor pest.

Sooty Mould.—This is a black fungus which grows on the surface of leaves in a thin layer in the honey-like secretion of such plant bugs as scale insects. It was very prevalent during 1937 in many districts. In all cases reported the scales were no longer to be found, but the mould persists for a long time after they have disappeared. It is not parasitic on the leaf in any way, and although it looks unsightly, it is not harmful.

C. B. REDMAN KING,

Entomologist.

REPORT

OF

THE AGRICULTURAL CHEMIST

FOR 1937.

Staff.—The Agricultural Chemist was on leave till August 7th. Dr. J. G. Shrikhande, Research Assistant, was absent on sick leave till July 1st. In the absence of these two officers on leave, the department was supervised by the Director, the Plant Physiologist and for a short period by the Biochemist.

Advisory.—448 letters were received and 395 replies despatched.

Lectures.—A lecture on "Salient Points in Tea Cultivation in Relationship to Green Manures and Shade Trees" was given before the Ceylon Association in London on February 3rd.

Visits.—10 visits were paid to estates.

Active prosecution of research necessarily suffered during the year on account of shortage of staff, but by the end of the year normal conditions were resumed, and both in the laboratory and in the field new lines of work have been put in hand. Whilst on leave, visits were made to the Rothamsted Experimental Station and to the School of Agriculture, Cambridge, from both of which information of direct application to local problems was obtained.

THE DECOMPOSITION OF GREEN MATERIAL.

The department has continued to investigate the decomposition of plant materials. Dr. Shrikhande, whose time is almost entirely devoted to this aspect, has been studying the transformations of nitrogen, carbon and lignin and their distribution in the finished material. This work is not yet at a stage for detailed report but there are indications that in the case of the specialised materials used, *i.e.*, green manures, the products formed, which are removable by hydrogen peroxide, are approximately constant in their composition with respect to nitrogen and lignin.

In recent annual reports the question of the necessity of composting has been examined in the light of the carbon-nitrogen ratio hypothesis. This approach was made necessary in view of the often repeated assertion that

the burial of green manures would involve severe and temporary nitrogen starvation. Taking the well established criterion of 10-12, these results showed that our green manures, when intelligently used, were of this order of carbon-nitrogen ratio and could be used with safety. Tea pruning leaf was a little higher but not higher than many composts.

It is a principle of sound scientific research that opinions should be backed by evidence, and that evidence should be sought along several different channels to see whether or not the items converge; if so, the opinion based on such findings becomes more valuable. In accordance with this viewpoint the question of suitability or otherwise of green manures for direct use has been studied by the direct method of following the nitrogen transformations involved. The procedure consists of rotting down under controlled conditions in the laboratory a given amount of the material of known nitrogen content in the presence of an amount of supplementary nitrogen sufficient to satisfy the nitrogen needs of the micro-organisms that are carrying out the fermentation. The nitrogen in the plant material is protein, an organic form. The added nitrogen is added as a chemical salt, ammonium sulphate or nitrate of soda. The reactions take place without any leaching losses and at the end of the rotting period the nitrogen can again be determined. In this connection it is important to mention that it is chemically exceedingly simple to distinguish between "organic" and "inorganic" nitrogen.

Where the material does not contain sufficient nitrogen to complete the disorganisation of the plant tissue into humus by the agency of micro-organisms, the added nitrogen will be brought into play and in the process will be changed to organic nitrogen because it is built up into micro-organic tissue. The difference between the organic nitrogen at start and finish expressed as a percentage of the dry matter under conversion is termed the "nitrogen factor." It measures the minimum amount of added nitrogen required for efficient rotting. In the case quoted it is positive. If the material does contain enough nitrogen to supply all microbiological needs, the excess is turned into mineral, *i.e.*, inorganic nitrogen. Such a state of affairs would lead to a diminution of the organic nitrogen and a gain in the inorganic nitrogen found at the end of the experiment. The nitrogen factor would be negative.

This type of determination is being carried out on a series of the commoner plant materials. For the present it is sufficient to report that in all cases where the carbon-nitrogen ratio is in the neighbourhood of 10-12 the nitrogen factor has been found to be negative, *i.e.*, the materials had no need of added nitrogen, and if incorporated into the soil, would not cause any nitrogen starvation. In the particular cases we are concerned with, the application of the general rule is thus confirmed by specific test and the evidence previously adduced is accordingly strengthened.

The diagrams, 1a, b and c illustrate the process by actual example. In 1a is depicted the balance of nitrogen in a material moderately high in

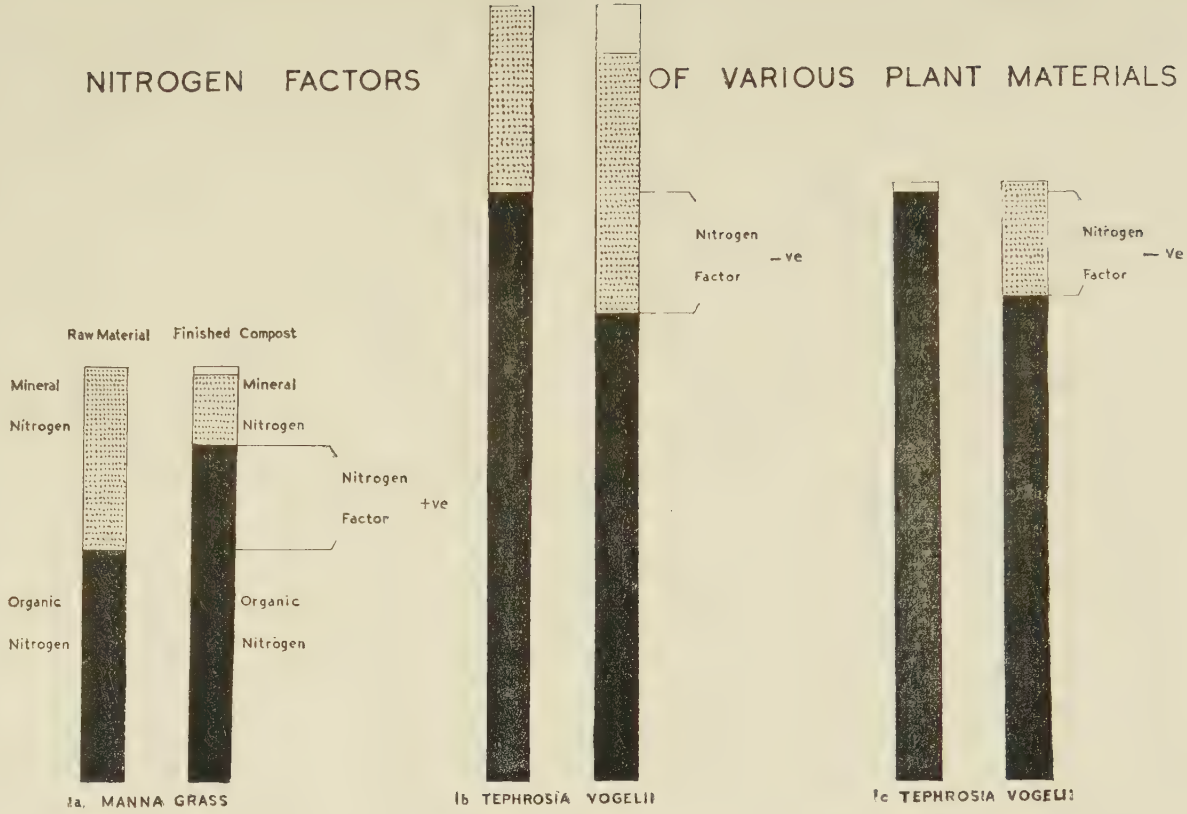
NITROGEN FACTORS OF VARIOUS PLANT MATERIALS
Raw Material
Finished Compost
Mineral
Nitrogen
Organic
Nitrogen
Mineral
Nitrogen
Nitrogen
Factor
+ve
Organic
Nitrogen
Nitrogen
Factor
— ve
Nitrogen
Factor
— Ve
Ia. MANNA GRASS
Ib TEPHROSIA VOGELII
Ic TEPHROSIA VOGELII

Figure I

carbon-nitrogen ratio. The solid portion represents the organic nitrogen and the stippled part the mineral or inorganic nitrogen. After decomposition the inorganic nitrogen is reduced as was previously described. In 1b, the process takes a different course. The carbon-nitrogen ratio is low, the nitrogen originally present abundant, and no battening on the added supplies has been caused; in fact they have been supplemented. 1c confirms this by showing what happens when no extra nitrogen is supplied. The blank portions of the diagram represent the differences between final and initial amounts of nitrogen. In two cases they are small and represent inevitable sampling error. But in 1b the amount is much too great to be thus accounted for. No nitrogen has been lost by leaching and the difference is thus attributable to loss in gaseous form. Such losses are one of the great dangers of using materials of high nitrogen content.

Translating these principles to a practical issue, there is the question of nitrogen loss when leaching can occur. Mineral nitrogen being soluble is more readily subject to loss than the organic nitrogen, and in fact all the nitrogen represented by the stippled areas and blank areas would be liable to dissipation in the compost heap.

As a practical demonstration of losses of the two kinds referred to, the fermentation of two experimental heaps of sunflower (*Tithonia diversifolia*) was arranged so that one was subject to the ordinary impact of the North-East Monsoon and one was protected by means of a roof. Table I gives the data collected from the experiment.

TABLE I.

LOSSES OF NITROGEN AND DRY MATTER IN COMPOST HEAPS.

Samples:	1	2	3	4
Rain				
Inches since previous sample	1.29	36.5	15.93	13.12
Moisture %.				
Covered ...	77.5	72.9	68.3	69.8
Open ...	78.7	78.8	81.0	82.4
Dry Matter loss % from initial				
Covered ...	30.6	53.2	56.3	68.0
Open ...	26.8	52.6	56.8	71.0
Nitrogen loss % from initial				
Covered ...	35.4	53.3	61.5	71.5
Open ...	19.2	51.4	60.3	72.0

From these figures several points emerge. During the early stages the moisture contents of the two heaps were very similar and dry matter was lost at about the same rate in both heaps throughout the course of the

experiment. Nitrogen too was lost at the same rate in both heaps if the first sample is excepted. The difficulties in sampling for analysis a material which was only partly rotted are sufficient to account for the large discrepancy in the nitrogen calculated for the two heaps on the first occasion. Furthermore nitrogen has been lost at approximately the same rate as dry matter. Since the two heaps behave so much alike the data can be amalgamated and the similarity of the loss curves for both constituents is then very strikingly brought out. The losses are rapid at first and gradually slow down. It is apparent that these losses are independent of the weather factor and are something inherent in the process itself. They are in fact the practical outcome of composting a material that is too rich in nitrogen. The carbon-nitrogen ratio hypothesis postulates that if the ratio is at the equilibrium point, losses of nitrogen and of carbon will take place proportionately and simultaneously. The above data demonstrate this. The carbon-nitrogen ratio of the material used is between 10 and 11, *i.e.*, at the equilibrium point.

The resulting compost is not thereby impaired as compost, nor as a manure, but even though the chief virtue of compost be something altogether apart from the ordinary nutritional elements that it contains, there seems no valid reason for throwing away a large contribution to the stocks of the most expensive of those elements. The remedy lies in two alternatives, either to refrain from composting solitary materials of high nitrogen content and always to mix these with more resistant material (all advocates of composting agree on this point) or to use such materials mainly as green manures.

Anyone who has seen composting operations as carried out in Ceylon cannot fail to appreciate in the light of these experimental results, the prodigal waste that is occurring, a waste that is all the more serious in its import in that it is taking place under the delusion that nutrient conservation is being enhanced.

FIELD EXPERIMENTS.

Nitrogen, Potash and Phosphate.—In the year under report the manurial experiment dealing with the plant nutrients nitrogen, potash and phosphate completed its second three-year cycle. In accordance with custom the yields are reported here. No new characteristic has emerged.

The opportunity was taken again to weigh pruning leaf and wood. There still exists a considerable body of planting opinion that imagines that, by manuring, the balance between "crop" and "wood" formation can be altered. Advice is frequently asked for manures that will increase and improve wood formation without increasing crop. No such magic is possible and the results just mentioned are an unmistakable demonstration of the fact. When the crop is compared with the pruning wood the results are as shown in Table III.

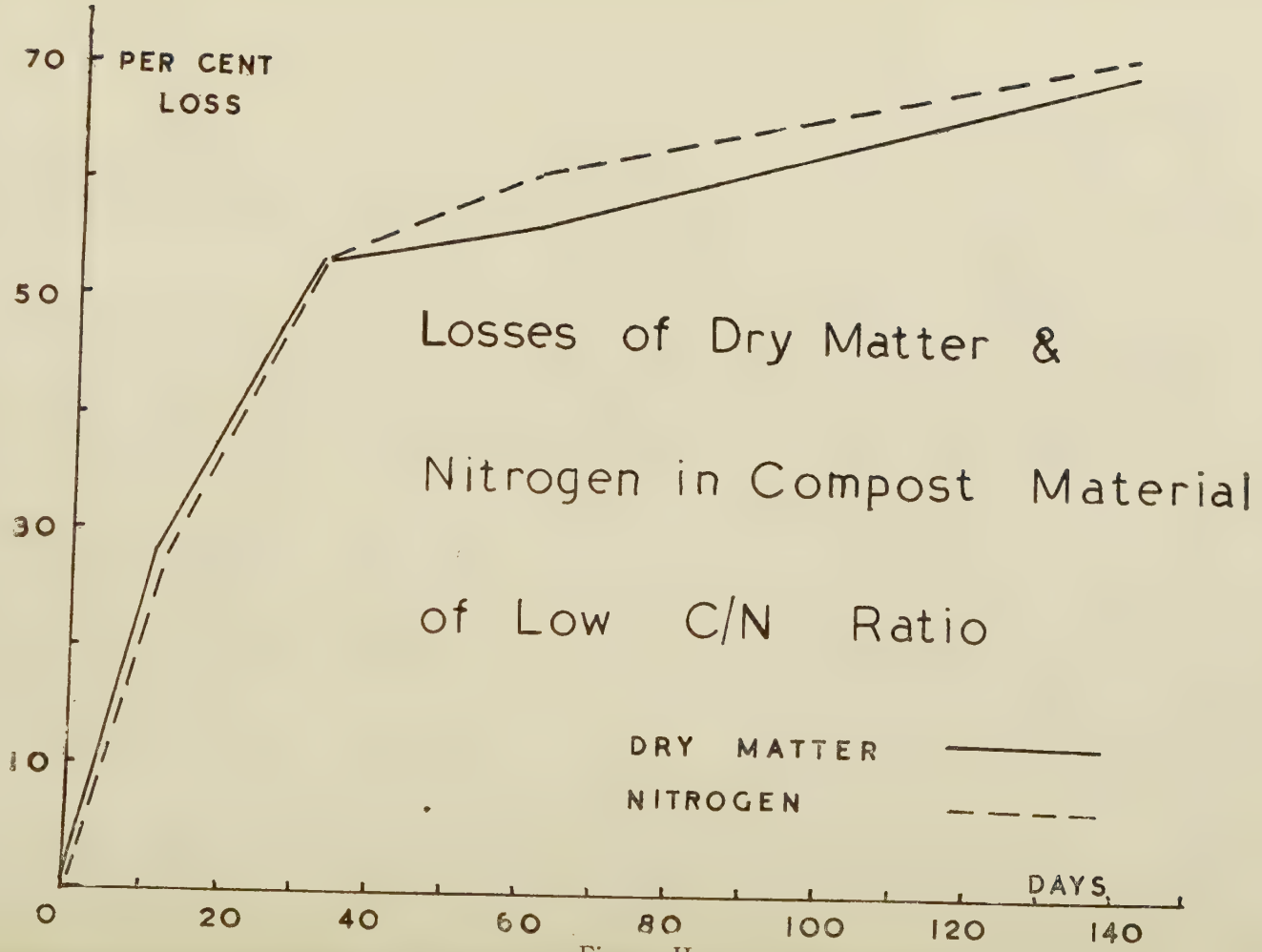
70
PER CENT
LOSS
50
30
10
0
20
40
60
80
100
120
140
DAYS
Losses of Dry Matter &
Nitrogen in Compost Material
of Low C/N Ratio
DRY MATTER
NITROGEN

Figure II.

TABLE II.

YIELDS FROM MANURIAL EXPERIMENT

ST. COOMBS.

Second Cycle; Third Year.

NITROGEN

Manurial dressing	0 lb. per acre	20 lb. per acre	40 lb. per acre
Yield per acre lb	482	571	673
Yield % of mean	84	99	117
Significant difference %*		6·7	

POTASH

Manurial dressing	0 lb. per acre	20 lb. per acre	40 lb. per acre
Yield per acre lb.	575	570	580
Yield % of mean	100	99	101
Significant difference %		6·7	

PHOSPHATE

Manurial dressing	0 lb. per acre	30 lb. per acre	60 lb. per acre
Yield per acre lb.	537	597	591
Yield % of mean	93	104	103
Significant difference %		6·7	

TYPES OF NITROGEN

Types of nitrogen Equivalent quantities	Sulphate of ammonia	Bloodmeal	Groundnut cake
Yield per acre lb,	645	611	609
Yield % of mean	104	98	98
Significant difference		7·25	

**The significant difference between yields is the amount by which one yield must exceed another, before it can be reliably stated that such yield differences are due to differences of treatment.*

TABLE III.

RELATIONSHIP BETWEEN CROP YIELD AND WOOD GROWTH.

	No Nitrogen	20-lb. Nitrogen per acre.	40-lb. Nitrogen per acre
Crop lb. ...	2072	2311	2553
Per cent mean	89.5	100	110.5
Wood ...	5200	5920	6880
Per cent. mean	87	98.5	114.5

No more complete proportionately in yield of constituent parts of a plant could be expected from any agricultural experiment. It is natural that this relationship should be closer in a crop such as tea where growth is entirely vegetative, than in orchard crops where both vegetative and reproductive growth occurs simultaneously, frequently in competition one with another.

Cultivation and Weeding.—The cultivation and weeding trial has run rather more than eighteen months. During this period the weeds have been colonising the ground, and it is a matter for remark that the process was on the whole so slow under our climatic conditions. One interesting observation has come out of this trial in regard to the type of weed that establishes itself. The frequent disturbance of weeds by forking every three or four months, upsets the natural balance of the weed flora in favour of weeds which produce large quantities of easily dispersible seed. The result is a large preponderance of tall weeds of the families *Compositae* and *Umbelliferae* which are not of any great importance as ground cover. The experimental plots soon showed a remarkable cover of *Gynura lycopersicifolia* and only later did low growing species begin to take hold.

The results so far obtained are quite tentative; they are only at present concerned with the effect of single factors. In the field one can seldom observe the working of a single factor. Thus cultivation is usually accompanied by the burial of leafy material and the effect of that operation is a compound of both soil disturbance and green manuring. To arrive at more than a superficial understanding of matters relating to cultivation and weeding it is essential to separate out the individual factors and their combinations. We are concerned moreover with the balance between various factors which are constantly changing in intensity. Consequently more than in the ordinary type of experiment dealing with manuring, there is the possibility that tendencies shown in early stages may diminish or be reversed later. Up to the present the results show no more than that existing notions about cultivation and weeding will repay close scrutiny. The figures tabulated below are yields per acre for the first 10 months of the second year of the experiment.

Clean Weeding	Selective weeding.
507 lb. per acre.	451 lb. per acre.
Forked once per annum.	Forked thrice per annum
494 lb. per acre.	464 lb. per acre.

Up to the present the data show that in the early stages selective weeding is accompanied by a falling off of yield, and that vigorous cultivation unless offset by some other desirable concomitant is also undesirable. These results are similar to those reported from Tocklai, but till more details are obtained over longer periods, it is not recommended that violent changes in cultivation practices should be made.

Compost and Green Manures.—The compost and green manure experiment which has been in existence since April, 1936 has not yet shown any definite results. Unfavourable seasons have lessened crop returns and militated against response to the treatments given, but at the present it cannot be said that in the face of these adverse climatic conditions any of the treatments employed has special efficacy. The absolute yields are not available in lb. per acre since the experiment is plucked on the intermittent 3-round principle. The relative yields are as follows. With the exception of the differences due to artificials in the absence of organic matter or in the presence of green manures, none of the differences is significant.

	No Organic matter.	Compost.	Equivalent green manures.
No artificials	91	103	93
Artificials (Nitrogen 40, phosphoric acid 30, potash 20).	105	100	109

In conclusion, it is a pleasure to thank all who have co-operated in these experiments and especially the Superintendents of Wikiliya, Gonakelle and Rookatenne estates.

T. EDEN,

Agricultural Chemist.

REPORT

OF

THE PLANT PHYSIOLOGIST

FOR 1937.

Correspondence.—392 letters were received. 481 letters were despatched.

Visits.—A total of 24 visits was made during the year while two lectures were given to District Planters' Associations.

Staff.—The Plant Physiologist relinquished acting charge of the Agricultural Chemistry Department on 6th August. During November he visited the Indian Tea Scientific Department's Laboratory at Cinnamara, Assam, and the United Planters' Association of South India's Laboratory at Devarshola, Nilgiris, South India. During his absence the Mycologist and the Agricultural Chemist assumed charge of the Division.

Botanical.—The species of *Artemisia* referred to in the Annual Report of 1936 has now been identified by Kew, through the good offices of the Economic Botanist at Peradeniya, as *Artemisia vulgaris, sensu latu.* The opportunity is taken to thank this officer for a great deal of help in identifying specimens.

An attempt to obtain information as to the value of a large number of species sent into the Institute for identification in view of their possible value as cover crops was made, and the Institute's thanks are due to the Superintendents who kindly supplied information. The information gained, however, was not as widely based as might have been expected, and it would appear that identifications are frequently requested of which no further use is made.

The following notes are based on the replies received, leguminous species being marked with an asterisk :—

Artemisia vulgaris (dwarf form). Deltota. This is not a good cover crop and is almost impossible to eradicate.

Lindula. Owing to suspicion as to its suitability, this has been excluded as a ground cover. It would be very easily established if required.

*Atylosia rugosa.** Bandarawela. Occurs on patnas. It did well among tea and was promising for some time, but subsequently disappeared. It was rather slow to spread and not easy to establish.

*Atylosia trinervia,** Lindula. Seeds itself satisfactorily and appears quite hardy.

Biophytum proliferum, Lindula. This plant is reported on as promising. It was planted out over a 13-acre field, and after two years gave promise of forming a complete cover over the acreage.

Cardamine hirsuta, Badulla. A surface rooting plant which does not prevent erosion during heavy rain.

Cardamine trichocarpa, Madulkelle. Reported on as making definite progress after three months of selective weeding and promising excellent results.

*Cassia mimosoides,** Lindula. Difficult to establish in quantity, but to be recommended to those who are looking for a thick cover.

Note.—On St. Coombs this has been found to multiply satisfactorily if allowed to seed freely.

Centella asiatica, Bogawantalawa. This forms too close a mat and seems to require a damp situation.

Hatton. It has a smothering effect.

*Desmodium heterocarpum,** Kotagala. It will grow quite well here, and it is proposed to cultivate it later.

Madulsima. It is common on the patnas in this district at and over 4,000 feet. It is easily raised from cuttings which should be put out during wet weather. Cuttings are easier and more economical to use than seeds, but self-sown plants are found among the tea. It is a most useful plant on road banks and above drains for holding up the soil. It stands the drought well and makes a quick recovery. It climbs if allowed, but is very easily controlled.

Ella. A suitable cover but will grow only on the better soils and is very slow to spread.

*Desmodium heterophyllum,** Ramboda. Grows well at 4,300 feet, but does not do well when transplanted to 5,700 feet. Does not require much control and is most useful.

Lindula. Does not multiply satisfactorily. It is very hardy in an open bed.

Desmodium triflorum,* Ella. Too close growing, being inclined to form a tight mat.

Note.—At low elevations this objection does not appear to apply.

Drymaria cordata, Agrapatna. Almost impossible to eradicate and may be expensive to control.

Hydrocotyle javanica, Lindula. Spreads very gradually but dies away in places and reappears elsewhere. It does not appear to climb.

Hydrocotyle sibthorpioides and H. mannia, Talawakelle. This has made a very fine cover during the wet months and it has done very well on steep slopes. Its growth is very vigorous in damp surroundings but it dies out during dry weather.

Lindula. It is proving an excellent ground cover.

Talawakelle. Forms a close mat with shallow roots. Requires to be kept under control. It dies back a good deal during dry weather.

Isachne Kunthiana, Bogawantalawa. This is reported as a "pernicious weed."

Laurenbergia wangerinii, Lindula. The spreading capabilities of this cover are very promising.

Halgranoya. It spreads in ravines and damp rocky places.

Oxalis corniculata, Matale. A useful light cover, but it dies down after seeding. Can be thoroughly recommended and is specially useful in clearings.

Ella. A suitable cover crop, but will grow and spread only in the better class of soils.

Parochetus communis,* Ramboda. The species is spreading gradually, but dies back temporarily during very dry weather. Transplanting has not been found to be a very successful method of spreading it.

Pilea angulata, Lindula. This failed to maintain itself.

Polygonum nepalense, Agrapatna. Grows fairly thickly; does not climb to any extent. It dies out in the dry weather and comes on again quickly.

Bogawantalawa. "This is an excellent weed to leave and I am leaving it all over my estate from next year."

Portulaca oleracea, Lindula. This species tends to die out and will not survive forking.

Sedum species, Talawakelle. Growth of this plant is very vigorous in damp rocky places, where it has formed a very fine cover.

Viola betonicifolia, Bogawantalawa. Too deeply rooting, and forming an insufficient cover over the soil.

*Zornia diphylla,** Madulkelle. It is suitable in habit, but does not form a sufficiently complete cover of the soil to be of real use. It is rather deep rooting.

The Relationship of the Characteristics of Made Tea.—The attractiveness of a beverage such as tea depends upon its effect upon the palate in relation to its cost and the convenience with which it can be prepared, and thus the estimation and comparison of the factors concerned in the two former criteria form an essential preliminary to research upon the improvement of the product. The terms used by tasters to describe the sensations registered on tasting are necessarily somewhat indefinite as are also the definitions of the various characteristics concerned. As an illustration, it was found that in certain teas some tasters considered flavour to be always detectable, but varying in degree, while others considered flavour to be present in only a very small number of cases. The latter judgments were not used in the present analysis, the number of available data being too small to permit of satisfactory test by the method employed. In this connection it may be noted in passing that it is to be hoped that the improvements achieved in the tasting of experimental samples will lead to less clumsy statistical methods being feasible than the present device to obtain information from rather difficult material.

Prior to the introduction of the "Team" system of tasting teas, a considerable number of samples had been examined by "Marking" in Colombo and we wish to take this further opportunity of acknowledging the ever-ready assistance we have received from the tea tasters. Taken as a whole the data referred to provide an opportunity of determining to what extent the various characteristics looked for in manufactured tea are associated. The importance of ascertaining this lies in the possibility of simplifications of tea terminology, and in the indications it may give of promising lines of further investigation. If, for example, two characteristics are always closely associated, it would suggest that either the characteristics are in reality the same, or that they are due to the same compounds in the infusions or to compounds whose occurrence in the tea leaf are interdependent or closely related.

Owing to the indeterminate range of the "Marking" and doubt as to the constancy of the value of one mark from occasion to occasion, even with one taster, it was decided to restrict the examination of the judg-

ments to the question (determinable from the marks allotted) of whether a given tea was equal to, better, or worse than that with which it was compared.

If two characteristics are independent of one another, in the sense that variations of one are unaffected by factors leading to variations of the other, it will be expected that they will, in a large series of trials, vary in the same and in opposite directions on an equal number of occasions. If a deviation from this equality is found to occur, of such magnitude that the likelihood of it occurring by chance is small, then evidence is provided that the hypothesis of independence is false.

As occasions on which one or both characters show no variation from the standard are not included in the test, since there is no possibility of attributing any definite frequency to them, and as no account is taken of the proportionality of the variations, it is considered desirable to adopt a high level of significance. The χ method of estimating the significance of the departure from equality in the two classes has been used and I wish to acknowledge Professor Engledow's criticism and help in interpretation. Yates' correction for small samples has been applied in the course of calculation.

In Table I the number of occasions on which the two characters (see column heading) varied in the same or in opposite directions, is given for each combination of the five characteristics examined.

Those cases where the probability of the observed departure from equality being due to change is less than .01, .02 and .05 are indicated by two lines, one line, and a dotted line respectively.

Before discussing the results it may be noted that some of the conclusions derived are already well accepted, but the results are of value in providing support from actual experiment.

The outstanding characteristic of the table is the close connexion between flavour and quality. In so far as "good quality" is most probably "an aggregate or balance of various characteristics with a desirable result," it is to be expected that quality will shew a positive relation with other palatal characters, but the closeness of the relation found is indicative that flavour is probably the most important determinant of quality. Pungency and quality show a similar close relationship. It is noteworthy that, in general, pungency and flavour show positive relationship. It may be said that progeny and flavour shew a general tendency varying in the same manner, and that quality is the reflection of these two characters with emphasis, possibly upon flavour.

The second noteworthy relationship is the positive one between colour and strength, and is suggestive of some possible relationship between the substances which give colour in the liquor and give a "full-bodied" sensation on the tongue. It is noteworthy that, whereas series in which the withering was the same shew close relationship, it is less close in the series where the withering treatment was varied. The small number of the data available in the nitrogen series render deductions dangerous.

Colour and pungency, colour and flavour, and colour and quality, vary in opposite directions in general in all the series but that in which leaf from different ages from pruning was compared, but in the latter series there are indications of the absence of such a relationship and even of its reversal. Strength and pungency appear to be independent save for a positive relationship in one series. The same remark may be made between the relationship of strength and flavour and strength and quality, but here the exceptions are negative.

The table provides an illustration of the complexity of the subject and also a suggestion that the superiority of tea made at the end of the pruning cycle over those made earlier may be due not only to emphasis of desirable characters but also in part to changed relationships among them.

It must be emphasised that the conclusions suffer from the limitation that they are all based upon teas derived from the same estate; the interrelations of the characters may not be the same when teas from different estates and districts are compared.

With the co-operation of two tasters some experiments were carried out in an attempt to determine the effect of smell on tasting, as it is well known that the tongue is on the whole a decadent sensory organ, capable of perceiving unaided only certain simple sensory effects, and that the finer points of what is called "taste" are in reality discernible only by the co-operation of the nose. As one taster pointed out, however, the danger of asphyxiation tended to interfere with accurate judgment during the tests! His general conclusion was that holding the nose during the tasting operation interfered with the estimation of flavour and also of quality; that both were interfered with supports the conclusion drawn from Table I of their association. The suggestion may be made that the aromatic properties of substances appearing in tea might well be the subject of investigation in any broad scheme of chemical research upon tea.

TABLE I.

SERIES		Colour and Strength		Colour & Pungency		Colour & Flavour		Colour & Quality		Strength & Pungency		Strength & Flavour		Strength & Quality		Pungency & Flavour		Pungency & Quality		Flavour & Quality	
		Same	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Same	Opp.
Withering		32	17	10	51	7	49	5	54	27	23	24	24	22	25	50	6	55	5	57	0
Pruning	1	44	1	12	30	18	29	17	35	15	24	15	27	15	35	34	16	36	16	55	0
	2	29	1	9	15	5	19	4	17	16	15	9	21	8	20	26	8	24	8	34	0
Age from Pruning	1-A	22	0	13	4	12	11	10	9	20	5	15	20	14	16	18	9	18	6	35	0
	1-B	24	0	14	7	19	6	16	6	17	11	17	15	16	12	23	5	21	3	30	0
	2-A	22	2	11	7	9	8	10	9	14	5	12	6	13	7	16	2	18	2	21	1
	2-B	24	1	13	9	7	12	7	11	16	9	16	5	8	13	15	7	17	6	21	1
Nitrogenous Manures		9	6	4	22	4	20	5	17	11	7	10	9	11	7	31	2	29	2	30	0

Selection of High-Yielding Bushes.—An area of tea at Galatura comprising 1,515 bushes was taken, and the number of shoots plucked per bush recorded for five rounds. The following classification resulted :—

Shoots		No. of Bushes falling into the yield classes shown
0-19	...	18
20-39	...	62
40-59	...	91
60-79	...	130
80-99	...	182
100-119	...	191
120-139	...	175
140-159	...	146
160-179	...	114
180-199	...	89
200-219	...	82
220-239	...	42
240-259	...	39
260-279	...	34
280-299	...	34
300-319	...	18
320-339	...	16
340-359	...	12
360-379	...	13
380-399	...	4
400-419	...	3
420-439	...	5
440-459	...	2
460-479	...	3
480-499	...	2
500-519	...	3
520-539	...	1
540-559	...	1
560-579	...	0
580-599	...	1
600-619	...	0
620-639	...	0
640-659	...	0
660-679	...	1
.....		.....
980-999	...	1

The comforting though that these figures represent an extreme case can be dismissed — the difference in type between bush and bush so painfully obvious in Ceylon tea fields is paralleled by as marked differences in yield, and while a proportion of this is undoubtedly due to extraneous causes, it may safely be said that even the crudest form of selection will produce at least some improvement. The figures above show that the vast majority of the bushes are low yielders — the problem is to select and to propagate high yielding forms having, if possible, other recommendations as well. The work is at present in its infancy but the Institute has already, in addition to its own work on the subject, assisted in outlining a scheme of improvement for an estate desirous of selecting high yielding types for use as seed-bearers — assistance which was reciprocated by the provision of useful information and suggestions based on the experience gained. While the Institute can naturally accept no responsibility for the actual selection or the trials on which they are based on individual estates, requests for information as to the best methods, in the light of existing knowledge, of carrying out work of this nature will always receive special attention.

Eighty-five bushes, comprising just over 5 per cent of the total examined at Galatura, whose yields were the greatest, were then examined for a further sixteen rounds. The average yields of these bushes ranged from 1.06 to 2.15 ounces green leaf per weekly plucking. The best yielders averaged 1.80, 2.15, 1.99, 1.90, 1.73, 1.79 and 1.90 ounces green leaf per weekly plucking. These figures are not as high as others that have been obtained, but this is probably due to the climatic conditions obtaining at the time. These bushes are now being propagated, together with others, for further test.

In the light of the experience gained, simplifications in the method of selection are being made, which will be the subject of later report. There is certainly no need to do such extensive flush counts before reducing the number of bushes to be recorded in the area under examination.

There are definite signs that commercial interests are realising the possibilities of selecting their own high yielders with a view to each estate acquiring its own group of bearers descended from proved high yielders. Such a trend is greatly to be desired, for it cannot be too strongly emphasised that, in a country with such diverse climates as in Ceylon, concentration upon any one selected type of seed may well lead to loss, and it is for *each* estate to attempt the discovery of the bushes which are the best *under its own particular conditions*. The progeny of such bushes might well be unsuited to conditions in a different district, and the aim should therefore be for each estate to possess at least amply sufficient

seed-bearers to allow of a supplying policy sufficient to offset the normal annual bush wastage. It is unlikely to be economic for many estates to maintain a larger area of bearers than this.

In this connection it may be recorded that a very good example of the improvement in uniformity of the progeny that can be achieved by even the roughest form of selection by eye of individual bearers was seen during the year. Where an estate has thirty or forty bearers or fewer to supply its own seed requirements, selection among them is relatively easy. It is very difficult, if not impossible, to form an accurate judgment of jât type from the appearance of the leaves of mature bearers and the best test is the crucial one of the *character of the progeny*. The seed from each bearer should be collected and sown separately, and the beds subsequently scrutinised for type. The bearers throwing undesirable progeny should be cut out, and the opportunity taken to eliminate any bearer producing seed having a low percentage germination, or producing seedlings of the desired type but with blotched or variegated leaves. The testing of individual bearers in this way costs very little, since the better seedlings can later be used for normal supplying, and it is beyond doubt the most satisfactory way of achieving uniformity of type where the number of bearers is small, although it does not allow of a very satisfactory selection on the basis of the vigour of the progeny.

Small amounts of replanting are now being done in Ceylon. It is to be hoped that care will be taken not to replant with material of the same infinity of types as was used for the original planting, but that full advantage will be taken of the opportunity of *improving* the type, vigour, and uniformity of the bushes by careful choice of the source of seed, and by rigorous selection of the young plants.

Propagation I.—*Budding*. This has been found quite feasible, but suitable buds are difficult to procure in sufficient numbers and there appear to be a number of factors affecting the success of the operation which require examination under Ceylon conditions and it is hoped to expand these investigations in 1938. An experiment was carried out to determine whether lanolin pastes (A) containing heteroauxin (1/600), (B) containing phenylacetic acid (1/450), or (C) without added "growth-controlling" substances, would vary in their effect upon the percentage of successful "takes" by affecting the production of wound tissue. The paste was applied on the outside of the bud after it had been inserted, the flap of bark being then replaced and the binding applied. The test cannot be regarded as a very accurate one, owing to the low percentage of "takes" achieved.

Sixty-seven buds used in each treatment gave the following "takes" :— A, 17; B, 15; and C, 14. The results are not promising, but it is hoped to examine the subject further when the technique of budding has been improved.

Injection of trees with phenylacetic acid solutions prior to budding produced no favourable results in an exploratory test.

II. *Cuttings.—Effect of Phenylacetic Acid.*

Planting material.—Terminal shoots, 2 inches to 3 inches long, bearing foliage equivalent to one medium-sized leaf, all treated with Buisol.

Treatments.—(a) Control: planted in coarse white silica grit in boxes covered with sheets of glass, and sprayed lightly hourly from 7-45 a.m. to 2-45 p.m. and at 3-45 p.m. watered till water ran from the box. Bottom heat was supplied from a boiler electrically heated (current on at 7-30 a.m. and off at 10-30 p.m. except on Saturday afternoons and Sundays, when it came on at 4 p.m. and off at 10-30 p.m.) Resultant sand temperatures were 22°-27°, being below air temperature in the morning and early afternoon, and above in the evenings and at night. Four 100 C.P. lamps were switched on at 4 p.m. and left on till 10-30 p.m. to somewhat reduce night respiration. The distance of lamps from boxes was 6 to 12 feet.

(The light intensity produced was low, but probably sufficient to produce photoperiodic effects. It seems likely that the production of flowers by T2, which had not flowered in ten years, but produced buds on the cuttings which opened and produced normal flowers, may be due to photoperiodic effects. If the viability of pollen from such flowers is satisfactory, such a method may provide a means of facilitating the crossing of shyflowering high jâts).

(b) *"P"*:—treatment as above, but the cuttings stood with their bases in tubes containing 0.1 per cent phenylacetic acid for 12 hours prior to planting.

(c) *"PV"*:—planted as above, but exposed to vapour of phenylacetic acid throughout the experiment. The penetrating odour of this substance suggested that minute traces might be absorbed over long periods by volatilization. Watering resulted in the bottles used in this experiment to contain the crystals becoming partially filled, but this did not prevent a strong odour being detectable. (It is now used in inverted small calibre tubes in which it has been fused.) Within a week evidence appeared of damage in the *P.* series, more numerous deaths occurring than in other series. It was later found that the bases of many cuttings in this series had died, the tops remaining alive. (See below).

Many young partially expanded leaves died in all treatments during the first week, the subtended bud and stem remaining healthy. In some cases actively growing buds also died, before any sign of death at the stem. The appearance at this time suggested that large demands for carbohy-

drates were prejudicial to the life of the cutting (cf. experiment No. IV). Banji buds subtended by a fully developed leaf seemed best, especially those about to break into growth. This was judged on visual appearance.

The results from the duplicate boxes in subsequent counts did not show good agreement, due partly to differences, produced by sunscorch. The following conclusions are, therefore, purely tentative, providing a basis for further examination.

(1). *P.* & *PV.* Resulted in a large number of cuttings showing growth of stem and leaves at an early stage.

(2). P. gave a smaller percentage of successful rootings throughout. Final figures were (after 9½ months) *P.* 7.9 per cent, *PV* 17.7 per cent, *Control* 17.2 per cent. (But see 7)

(3). No root proliferation along the stem, such as has been recorded in other plants, was seen, although injection of 1 ml of 1 per cent phenylacetic acid into a rooted plant produced leaf crinkling.

(4). The rooting rate of *P* cuttings recovered after removal of the dead bases 2¼ months after planting, and was then about the same as the other two treatments.

(5). *P* & *PV* had no significant effect on the percentage of cuttings alive after 9½ months.

(6). Heavy callusing occurred in all series. It was periodically pared without noticeable effect on rooting.

(7). Variations in percentage alive after 9½ months were large due to sunscorch. Calculating number of plants rooted as a percentage of the total remaining alive after 9½ months to eliminate this effect, the results were:—

P.	*PV.*	*Control*	
23.4 per cent	58.1 per cent	41.7 per cent	Sig. Diff. 15.0 per cent

i.e. *PV* > *Control* > *P.*

The use of phenylacetic acid vapour as a suitable method of stimulating rooting is being further examined.

Cuttings III.—*Effect of Nicking.* Nicking the stems half way through and covering the cut with adhesive plaster three weeks before taking the cutting, so that half the base of the cutting was already callusing, had no significant effect in increasing the percentage alive after 9½ months, of the number rooted, expressed as a percentage either of the original number or of the final number alive.

A further experiment, designed to test the effects of phenylacetic acid vapour and of sand and peatmoss as rooting media, is in progress. The latter medium already appears to be giving distinctly better results than the former.

IV. *Cuttings.—Effect of Enhancing the Supply of Nitrogen and Carbohydrate, and of Adding a Growth Regulating Substance.*—Preliminary tests on shoots of tipping character showed that concentrations of dextrose above 3 per cent, and of urea above about 0.20 per cent, produced injury, after immersion for 24 hours. Stems of T11 were scrapped to the cambium just below each leaf on two sides, the injury being covered by sticking plaster. 24 days later the stems were removed and the bases of half stood in distilled water for 42 hours, the rest being placed in a solution of dextrose (2.5 per cent)+urea (0.1 per cent)+phenylacetic acid (0.004 per cent). Rooting after 7 months was poor, in the first 1.2 per cent and in the second 3 per cent. The percentage alive after 7 months was 21.7 per cent in the first case, and 45.8 per cent in the second.

Further test with a more easily rooted type is desirable.

V. *Root Cuttings* appeared to be far too slow and therefore a practical failure under our conditions. No shoots have been produced from 266 root cuttings planted in coarse sand in an outdoor frame after 6 months.

VI. *Inarching* is quite successful but very slow. It needs to be done on green, rapidly growing tissues and the scion should not be severed for at least three, preferably four or five months at this elevation (4,500 feet) or the union will not be good enough to ensure an adequate supply of water to the scion after planting out.

VII. *Growth Habit.* In close T2 an interesting case of a lateral branch, when inarched onto a tall stock at 4 feet from the ground, producing a fan shaped branch has been noted. Gardenias are said to show a similar effect, lateral shoots producing stocky plants which flower early, and leader shoots vigorously vegetative plants.

VIII. *Grafting* onto seedlings and onto root cuttings was a failure, due to invasion by bacterial slimes under the very moist conditions in which they were kept. Grafting will probably not be a feasible commercial method in Ceylon, although it may be noted that in Java clonal material for crown grafting of tea is advertised commercially. A method of grafting onto very young seedlings is being examined for use with shy-rooting clones.

IX. *Type of Cutting.*—Halving the stem of single node cuttings longitudinally appeared less desirable than the normal treatment. One case of a leaf without a stem or bud producing roots was found.

X. Noteworthy clonal differences in the percentage rooting from single node cuttings were found, *e.g.*,

T9. 63.5 per cent rooted in $6\frac{3}{4}$ months.
T11. 1.2 per cent rooted in 7 months.

XI. Grafting freshly germinated seedlings with dissected buds from flush has twice been a failure. In the second case heteroauxin in lanoline was applied in the hope of stimulating cambial activity. All that happened was that the buds did not die so quickly as in the first trial. The extreme cheapness of such a method as this, if the conditions for its success can be found, warrant its further examination.

Effect of Additional Internal Nitrogen on Establishment of Stumps.—48 plots of 10 plants each were used to examine the effect of soaking the roots of 2-year-old seedlings, stumped at 18 inches above the collar prior to planting, for about 15 hours in 0.25 per cent urea, 240 plants being treated and a further 240 plants used as controls. The following observations were made (the results are given up to the termination of the experiment):—

Date	Nitrogen	Control	Difference
Number of plants bearing expanded leaves.			
13-11-37 ...	57	43	Significant
13-12-37 ...	98	79	,,
12- 1-37 ...	107	85	,,
14- 2-37 ...	113	85	,,
Number of plants bearing expanded leaves over 12 inches above the collar.			
13-11-37 ...	37	24	Not significant
13-12-37 ...	68	61	,,
12- 1-37 ...	75	63	,,
14- 2-37 ...	75	62	,,
Number of plants bearing expanded leaves between 6 inches and 12 inches above the collar.			
13-11-37 ...	41	32	Not significant
13-12-37 ...	63	59	,,
12- 1-37 ...	84	67	Significant
14- 2-37 ...	88	67	,,
Number of plants bearing expanded leaves between 0'' & 6 ins. above collar.			
13-11-37 ...	36	24	Significant
13-12-37 ...	74	50	,,
12- 1-37 ...	76	56	,,
14- 2-37 ...	84	56	,,

The low figures for plants showing growth are due to the effects of a prolonged drought following planting. It is of interest to note that the increase in the number of plants bearing expanded leaves was associated with a larger number of plants in the nitrogen series producing shoots near the ground level. This effect needs further investigation, as it has an obvious practical bearing.

From 11-3-38 to 13-3-38, measurements were conducted on the number and weight of shoots produced since planting, and on the weight of dieback (removed by cutting back until living wood was reached). No significant differences were detectable in the total weight of shoots or of dieback, but the number of shoots, 883 in the nitrogen series, and 723 in the controls, showed a significant difference. Further data collected show that there was no significant difference in the total weight or number of shoots produced per living plant, nor in the mean weights of the individual shoots produced by the plant in each treatment. Thus the gross effect is due to the larger percentage of plants successfully established.

Effect of Phenylacetic Acid on Establishment of Stumps.—An experiment consisting of sixteen randomised blocks, each containing eight plots of twenty-four plants, was devised to determine the effect of soaking the taproots of two-year-old stumps (cut at 18 inches above the collar and all leaves and lateral branches and roots removed) in various concentrations of phenylacetic acid overnight. The concentrations used were :—

P	Q	R	S	T	X	Y	M
0.584%	0.293%	0.193%	0.074%	0.038%	0.017%	0.008%	nil

Planting was carried out from 31st August to the 5th September. Examination of the table below shows that even if any stimulation of root production occurred in the weaker concentrations, it was insufficient to affect significantly the number of plants producing new shoot growth during the period, while the production of new shoot growth over the stem remained unaffected. A concentration between 0.193 per cent and 0.074 per cent appears to mark the maximum permissible, above which damage occurs.

	Date	P.	Q.	R.	S.	T.	X.	Y.	M.	Sign. Diff.
No. of plants	11-11-37/13-11-37	118	184	193	233	241	244	240	231	41.91
bearing	9-12-37/10-12-37	143	239	254	306	319	296	314	316	32.91
expanded	10- 1-38/11- 1-38	179	264	280	329	341	323	332	335	28.35
leaves.	10- 2-38/11- 2-38	181	266	286	335	342	327	332	337	30.70

	Date	P.	Q.	R.	S.	T.	X.	Y.	M.	Sign. Diff.
No. of plants bearing expanded leaves over 12 inches above the collar.	11-11-37/13-11-37	60	116	132	151	177	128	152	164	26.05
	9-12-37/10-12-37	94	177	203	234	246	219	244	234	30.06
	10- 1-38/11- 1-38	120	209	220	253	270	240	255	260	32.05
	10- 2-38/11- 2-38	120	210	226	251	268	234	253	264	30.63
No. of plants bearing expanded leaves between 6 and 12 ins. above the collar.	11-11-37/13-11-37	72	140	160	177	188	177	197	182	24.33
	9-12-37/10-12-37	109	206	216	253	264	254	264	260	30.69
	10- 1-38/11- 1-38	144	228	238	279	288	284	295	279	32.09
	10- 2-38/11- 2-38	142	230	240	283	292	288	294	285	30.93
No of plants bearing expanded leaves between 0 ins. and 6 ins. above the collar.	11-11-37/13-11-37	63	123	113	157	171	148	164	165	24 92
	9-12-37/10-12-37	102	166	175	230	253	224	236	252	35.09
	10- 1-38/11- 1-38	122	186	194	237	268	245	251	256	33.60
	10- 2-38/11- 2-38	135	188	192	249	268	252	251	255	34.16

The weights of dieback determined between 1st and 10th March, 1938 agree, as is to be expected, with the foregoing results as does the dry weight of new growth produced per plot and the number of shoots per plot.

	P.	Q.	R.	S.	T.	X.	Y.	M.	Sig. Diff.
Total Dieback	1658	1112	1019	576	464	741	586	495	279
New growth	114.5	197.8	234.0	335.3	364.0	312.2	295.6	346.7	73.0
Shoot number	1420	2043	2333	2708	2987	2726	2917	2831	388
New growth per growing plant	0.56	0.73	0.80	0.98	1.08	0.95	0.87	1.04	0.25
Shoot number per growing plant	7.81	7.88	7.94	8.19	8.69	8.38	8.81	8.50	None
Mean weight one shoot	0.072	0.094	0.100	0.122	0.127	0.152	0.994	1.256	None

The new growth per growing plant also exhibits a reduction after treatment with the higher concentrations. Not only, therefore, have the latter prejudiced establishment, but also the growth of the plants that survive. The significant effect upon growth noted above is the result of the combination of shoot number and mean weight per shoot, neither of which, however, show significant differences among themselves.

Leaf Development.—A new leaf appears to develop on the shoots produced after pruning on the average every six or seven days at this elevation. The estimation of the interval between the unfolding of successive leaves is of considerable importance in settling the best length of plucking round and it is intended to make experiments on the subject during 1938.

Pruning.—In amplification of the records noted in Bulletins Nos. 15 and 17 the following results obtained during 1937 should be noted:—

Young Tea.

Treatment	A	B.	C	
1937 February	Tipped.			
March	Brought into plucking			
September		Cut across ½ in. above last tipping level.	Cut across ½ inch above last tipping level.	
December		Brought into plucking.	Brought into plucking.	Sign. Diff.
Thickness of stem at ground level	4.75	5.17	4.63	—
Increase since prior measurement	0.36	0.89	0.64	—
Breadth of bush at 18 ins. in cm.	76.02	103.55	107.77	9.20
Increase since prior measurement	−21.46	+26.05	+26.33	13.02
Annual Yield 1936-37	246.89	629.93	545.69	81.91
Total Yield to 1-7-37	572.43	702.88	940.49	123.86
Yield per plucking 1936-37	10.29	15.75	15.16	3.56

Year dating to 1st July.

The increase in thickness of the stem at ground level shows no significant difference, probably because the effect of the pruning is spread over the years 1936-37 and 1937-38. The pruning has naturally reduced the spread of the bushes in the A series, no difference being found between the series B and C, which received rather similar treatment.

The results still suggest that it is desirable to bring young tea into bearing as early as possible, and that the increase in crop thus obtained is not at the expense of the growth of the frame.

Old Tea.—The comparison of clean-pruning, rim-lung, and fringe-pruning at St. Coombs (4,500 feet) has given the following results per 3,000 bushes :—

	Clean	Rim-lung	Fringe	Sign. Diff.
Total tippings	250.17	222.29	283.48	10.33
Average size of tipping shoots	3.56 gm.	3.90 gm.	3.55 gm.	—
Yield after 9 months :—				
January pruned	130.08 lbs.	109.56 lbs.	127.92 lbs.	12.48
May pruned	88.32	90.84	100.32	8.16
September pruned	146.16	145.68	159.24	11.16
Yield after 12 months	251.24	245.87	262.43	—
Yield after 18 months	537.67	516.83	536.14	—

Examination of the results reveals some interesting points.

Fringe-pruning resulted in a better recovery as judged by weight of new tipping growth than did clean-pruning, the latter being again found to be superior to lung-pruning *at this elevation*. The size of the shoots, as judged by the average weight of the portions removed by tipping, did not differ significantly in the different treatments. The relative yields after nine months were found to vary according to the season at which pruning was done, but at all three seasons fringe-pruning gave an increased yield over lung-pruning, and over clean-pruning at two out of the three.

At twelve and eighteen months no significant differences were found to remain; it has previously been suggested that the full results of fringe pruning would not be achieved until it had been carefully practised for several cycles, but the demonstration of actual yield results achieved so rapidly should induce an increase, long overdue up-country, in the amount of attention paid to this subject.

Experience has shown that the differences in cropping capacity produced by different methods of pruning tend to decrease markedly in the later years of the cycle. In view of the absence of differences towards the end of the first half of the cycle, it was decided to record for the remainder of the cycle only the fresh weights of leaf harvested, but to maintain the experimental manufactures and the crop analyses now in progress.

The latter consist of careful examination, at every alternate plucking, of the percentage of banji shoots, the plucking standard, and the relative proportions of the component parts of flush and banji shoots. There is evidence, supporting that which has already been published, of age trends that are superimposed upon the normal seasonal fluctuations; it is, however, not proposed to report these investigations until they are more complete.

The opportunity is being taken to obtain further information on the relationship between the nitrogen level in the shoot and the proportion of banji shoots in the crop harvested.

The experiment at Galatura will be discontinued as from the end of this cycle; this will permit of increased attention being paid to selection work. At the commencement of this, the third cycle, the bush numbers per plot were readjusted to 250 bushes per plot by inclusion of supplies and weak bushes that had previously been rested for considerable periods. As will be seen below, the clean-pruned plots have yielded practically as much as the rim-lung plots—a result that is easily explicable when it is remembered that vacancies resulting from deaths after pruning were far more numerous in the clean-pruned plots than in the lung-pruned plots. Thus a large number of bushes which had been rested for several years, and were therefore unlikely to suffer from clean-pruning, were included.

The results do not, therefore, provide a strict comparison of the two treatments. The mean yields per plucking in lbs. per 3,000 bushes were, clean-prune — 16.08 lbs., lung-prune 16.68 lbs. and travancore 23.18 lbs. during the first year after pruning. As in the previous cycle, the travancore prune has given very satisfactory yields. The experiments have undoubtedly proved the very satisfactory nature at this elevation of a system of alternating a variable number of travancore prunes with periodic lung-prunings to facilitate sanitary work in the interior of the bush. As in previous years we desire to record our grateful thanks to Messrs. James Finlay & Co., Ltd. and the Amalgamated Tea Estates Co., Ltd. for their generous assistance.

Particular attention is drawn to the section in the Mycologist's report dealing with clean-pruning at low elevations in Ceylon. It should be unnecessary after this lapse of time to draw further attention to the conclusions reached on this subject, and reported fully in Bulletin No. 15 and in prior publications.

It is of interest to note that a case of carbohydrate deficiency occurring at a relatively high elevation as a result of clean-pruning subsequent to a period of rapid growth in a "rested" field was found during the year. In the Annual Report for 1933 Bulletin No. 11) it was pointed out that resting during a "rush" period might prove of little value in cases of carbohydrate deficiency. The case mentioned provides an example where it was actually disadvantageous, even under circumstances where carbohydrate deficiency would not normally have been suspected. Care should be taken to prune rested tea either at the very commencement of the "rush" period, before the bush has used up its reserves in the rapid production of new growth or after a period of slow growth has succeeded the rapid growth.

Grateful acknowledgment of facilities extended for the conduct of an experiment on dieback is made to the Scottish Tea and Lands Co. Ltd. and to the Superintendent of Sarnia estate.

F. R. TUBBS.
Plant Physiologist.

REPORT

OF

THE TEA TECHNOLOGIST

FOR 1937.

Staff.—The staff remained unchanged. The Tea Technologist took over acting charge of the Agricultural Chemistry Department during the months of May and June.

Correspondence.—484 incoming letters were filed in the Department and 432 despatched. A considerable amount of correspondence would be saved if reference were made to *The Tea Quarterly* and associated Bulletins before sending in requests for advice on fuels, firing, moisture content, etc., which have been dealt with quite thoroughly from time to time.

Samples.—232 samples of tea leaf were received for various purposes.

Estate Visits.—During the course of 1937 it was found necessary to restrict slightly the number of estate visits and it is hoped that the attitude of the Department will not be misunderstood in this matter.

It is obvious that absence of officers on visits, especially at irregular intervals, is liable to interfere with the primary task of research although the necessity for keeping in touch with general practice is fully realised. We make special arrangements however to see new factories and machines, or to see new ideas in practical form, and visits will, of course continue to be made for advisory purposes where such advice cannot satisfactorily be given by correspondence.

There has been a tendency for a number of estates to send in requests for tests to be carried out on dryers immediately after installation, in some cases before the machine is handed over by the engineer responsible for its erection. After careful consideration of the matter we are of opinion that this is not the best procedure and we have, therefore, asked the estates concerned to postpone application for a visit until the engineers have expressed their satisfaction with the working of the new installation. After this, if the estate is not satisfied with the machine, or if any definite difficulties arise in which our services are likely to be of value, we can generally arrange a visit with the minimum of delay.

Whilst laying special emphasis on the fact that there is not any trained engineer or trained tea taster on the staff of this Department, the special equipment with which the Department is provided and the experience gained of such work enables us to detect most technical faults that are likely to arise. The remedy for such faults is usually in the province of the engineer, and we rely on the tea taster in Colombo or London to say when satisfactory results are being obtained.

In general we may be regarded as *liaison* officers between the engineer and the taster and if, when difficulties arise in any factory, it is considered that we can render useful service in this capacity, there will never be any difficulty in arranging for a visit by an officer from this Department.

During the early part of 1937 we had several requests to visit factories where there was not any definite difficulty with manufacture but where better results were considered possible; that is to say that we were asked to visit in the capacity of a scientific visiting agent. This type of work is really rather beyond the scope of activities at present envisaged for this Department since it is probable that every factory in Ceylon could make some improvement in their methods of manufacture, and if our aid were sought in every case, we should need three or four days to become acquainted with conditions in each factory after which we should have to visit at intervals sufficiently often to keep in touch with carefully planned experiments.

When visits are requested it is asked that full details of the problem at issue may be supplied in advance. This will probably reduce the time required for the visit.

During 1937 sixteen factories were visited by the Tea Technologist, one by Mr. Keegel and one by Mr. Perera.

Visitors to St. Coombs Factory.—It is gratifying to record that a large number of people have visited the laboratory and factory during the year. There are on record 130 names of visitors (exclusive of the January conference) apart from which there must have been at least another 20 or 30 visitors who did not sign the visitors' book or who did not make appointments.

It will be a matter of great convenience to this Department if visitors can arrange their visit for the last Wednesday of the month or, if this is not possible, make an appointment. As it takes on the average one hour to go round the factory and to discuss various points of interest a good deal of time is saved if visiting can be arranged in advance. Apart from the general convenience of such arrangements, officers may be absent or unable to allot the necessary time to visitors who give insufficient notice.

ANALYTICAL.

At the request of the Ceylon Association in London further analyses of Ceylon teas were carried out in connection with Food and Drug Laws.

These analyses curtailed the work in the Biochemical Section of the Department but in view of the importance of the issues involved this could not be avoided.

Every effort is made to keep the Department in touch with the Food and Drug Laws of all countries to which tea is exported, and the Department is well equipped to provide all analytical information required in connection with the maintenance of the purity of Ceylon tea.

Miscellaneous Analyses.—Apart from the figures given under other sections of this report the only analyses of general interest were of teas from a factory where it was suspected that high firing caused excessive loss of caffeine.

Sample	% Moisture	% Caffeine.
1. Withered leaf ...	—	3.0
2. Fired tea ...	1.2	3.6
3. ,, ,, ...	1.5	3.0
4. ,, ,, ...	0.8	3.2
5. ,, ,, ...	2.1	3.4

There was therefore no supporting evidence for the suspicion.

The nitrogen content of 103 samples of tea were determined for the Plant Physiology Department.

BIOCHEMICAL.

As mentioned above, the work in this section was curtailed owing to an analytical investigation which took up a considerable amount of Mr. H. B. Sreerangachar's time. In the Annual Report for 1936 it was recorded that Mr. Sreerangachar had been engaged to assist with the biochemical investigation of tea leaf and a certain programme in this direction was described.

The Tea Technologist was able to spend some time personally on this work and very encouraging progress was made during 1937.

It is not proposed to go into close detail in this report but it should be recorded that we have made what is believed to be a quite original contribution to the knowledge of the mechanism of enzymic fermentation of tea. The results obtained will eventually be published in a scientific journal but before this is desirable it is necessary to obtain apparatus for the ultimate analysis of the various products isolated from fermented tea leaf. The apparatus is on order and the investigation should make considerable progress in 1938.

Enzymic Fermentation.

Enzyme Activity in Relation to Withering.—The results obtained in this connection confirm the previous observation that during withering there is a progressive increase of enzyme activity in the leaf. The question

whether it is due to a gradual elaboration of more enzyme as a result of the cellular activity of the withering leaf or whether some specific accelerators are also involved, deserves further attention. Attempts will, however, be made to detect such accelerators if they should exist.

Purification of the Oxidising Enzyme in Tea.—In order to study the nature of this enzyme in greater detail, attempts were made to purify it from its associated inactive substances. The enzyme extract employed for this purpose was derived from the acetone-dry preparation of the fresh leaf. The methods employed were (a) Alcohol precipitation, (b) Half saturation with ammonium sulphate, (c) Ordinary dialysis, (d) Ultrafiltration, and (e) Adsorption. Of these, the first two methods had a definite tendency to inactivate the enzyme. Dialysis of the enzyme solution was conducted against distilled water employing both collodion and parchment membranes. The dialysed enzyme was found to have lost almost all its activity during the process. The question then arose whether some necessary accelerator was removed from the enzyme complex during dialysis. An ultrafiltration of the enzyme using collodion membrane showed, however, that that membrane was pervious to the passage of the enzyme. In an attempt to absorb the enzyme, two well-known adsorbents namely, Alumina C and Kaolin were employed adhering to the necessary conditions of the experiment in each case. It was found that the enzyme was not adsorbed by either of these and as such they were not useful in the adsorptive purification of the enzyme.

Influence of Copper and Manganese.—The concept of some specific accelerators being removed from the enzyme solution during dialysis thus rendering it inactive led to the investigation of the effect of manganese and copper on the dialysed enzyme. A series of experiments was therefore conducted adding manganese and copper to both dialysed and undialysed enzyme in order to see if the activity is restored in the former case and increased in the latter.

It can be concluded from the results obtained that neither copper nor manganese is able to restore the full activity of the dialysed enzyme, despite a slight tendency in that direction, particularly noticeable when both copper and manganese are added together. The action of the undialysed enzyme is also slightly accelerated by similar additions. It is interesting in this connection to note that even the ash of the original enzyme when added to a dialysed enzyme is not able to restore its full activity. It may therefore, be possible that an accelerator, organic in nature, is also involved.

Mechanism of Enzymic Fermentation of Tea.—By the direct precipitation of tea leaf juice with alcohol an almost tannin-free enzyme preparation may be obtained. An investigation of the enzymic activity of this precipitate revealed a striking resemblance to tyrosinase described by Raper and others, the main distinction being the inability of the tea leaf enzyme to act on monohydric phenols to produce dihydric phenols or their derivatives.

Thus, the tea leaf enzyme will produce orthobenzoquinone from catechol which may be isolated in the form of an aniloquinone derivative. Similarly the enzyme will react with protocatechuic acid, pyrogallol, gambir catechin and a tea catechin.

Furthermore, the most important fact from the point of view of tea manufacture is that the enzyme reacts with tannin preparations derived from tea with the formation of similar red compounds which are readily decolourised by sulphur dioxide. Tea liquors brewed in the ordinary way readily lose their desirable red colour when treated with sulphur dioxide, and become bright yellow in exactly the same way as a solution of orthobenzoquinone prepared by the action of the enzyme upon catechol.

Without placing too broad an interpretation upon the evidence so far available, it appears safe to say that it is extremely probable that one of the changes taking place during the fermentation of tea, and one which contributes to the production of redness in the liquors, is the formation of quinones from the polyphenolic substances present in the leaf. It should be borne in mind that other enzymes besides those present in the alcohol precipitate may take part in fermentation carried out under natural conditions, but nevertheless a promising line of enquiry has been opened up and it is to be hoped that investigation of the pure chemistry of the problem will prove feasible.

If the scheme for the joint employment of a chemist by the various research institutions bears early fruit, it is quite possible that an investigation of the phenolic substances of green leaf will readily yield information of considerable utility, especially in connection with the fermentation of tea. Knowledge of the exact nature of the substances present in green tea leaf would certainly assist biochemical investigation and should as a result have considerable commercial value.

Splitting of Gallic Acid from Tea Tannin by Aspergillus Niger.—Deijs and Dijkman (*Thee Archief*, 1936, page 189) of the Java Experimental Station, working with Java tea leaf, have demonstrated the formation of free gallic acid from a preparation of tea tannin by the action of *Aspergillus niger*. An attempt to repeat this observation with Ceylon tea leaf was made, and Dr. Gadd, the Mycologist, very kindly supplied us with a pure culture of *Aspergillus niger*. It was found that this culture would liberate gallic acid from a sample of commercial tannic acid.

Vigorous growth of the culture was obtained on a medium containing theotannin prepared by a method described by Shaw of the South Indian Research Station, but there was no increase in the amount of gallic acid present in the medium.

It is of interest to note that in Java the theotannin prepared by Shaw's method was found to be free of gallic acid, whereas working with Ceylon leaf we found considerable quantities of gallic acid in our preparation made by the same method.

Preparation of Catechins.—Various catechins described in the literature have been prepared as substrate for the experiments on the mechanism of enzyme fermentation. Amongst these were Gambir catechin, Acacia catechin and two catechins described by Japanese workers in connection with tea. The Japanese workers used Formosan leaf for their preparations and it is of interest to record that although small quantities of definite catechins were isolated from Ceylon leaf they were present in much smaller quantities than reported in Formosan material.

Biochemistry of the Tea Leaf.—The general programme of work on the biochemistry of tea leaf is now well defined and although difficulties will probably arise with the isolation of, and preparation of derivatives of, the products of the action of enzyme preparations upon the more complex catechins and tannins of the tea leaf, extension of the investigation to a study of the action of the enzymes upon other polyphenols of established constitution may give some useful information.

Some attention has been given to the presence of flavones and anthocyanins in tea leaf, both of which may be of importance in the colour of tea liquors.

A Japanese worker has isolated Kempferol from Formosan tea leaf and the literature contains many references to Quercitrin in tea leaf.

The close relationship between catechins, flavones and anthocyanins makes a consideration of these groups of colouring matters of added interest. It should also be recorded that a pigment believed to be a red anthocyanin has been extracted from the leaves of certain bushes on St. Coombs estate, and that one bush having particularly highly coloured flush is being propagated to provide sufficient material for further investigation. The flush from this particular bush has been manufactured separately, and gives a very high coloured liquor; the infusion is, however, very dark and abnormal.

While the rôle of tannins in the metabolism of the tea bush is a subject for much thought and investigation, it is not at all improbable that highly coloured pigments may arise from them or through a common metabolic mechanism. The close chemical relation between the well-known groups of plant colouring matters and tannins is possibly worth bearing in mind when investigating the development of colour in tea by enzymic fermentation.

Chemical Composition and Quality.

Nitrogenous Manuring.—In the last report a number of analyses of leaf from plots receiving different levels of nitrogenous manuring were given. The figures showed that 40 lbs. nitrogen per acre as against no added nitrogen tended to depress the tannin content of the leaf but did not affect quality. In the case of experiments concerned with age from

pruning it was found that tannin content and tasters' valuations were closely related and the view was expressed that although tannin content was almost certainly related to quality, other factors had to be taken into account.

Dr. Eden's manurial trial plots, from which the leaf was obtained, were pruned in March but a few further figures were obtained in February and early March.

		Total oxidisable material.	%Content soluble theotannin derivatives. (Calculated on dry matter)
February	No nitrogen	312	29.6
	40 lb. nitrogen per annum	294	27.1
March	No nitrogen	277	25.8
	40 lb. nitrogen per annum	282	26.4
,,	No nitrogen	287	26.6
	40 lb. nitrogen per annum	302	28.0

In the flush from the last two pluckings a complete reversal of the relative tannin status was shown, which may be a seasonal effect, or may be connected with changes in the nitrogen status of the soil and the plant. It is however idle to speculate on this at present and it is intended to follow the changes taking place in the next cycle of this manurial experiment, through a large number of samples.

Pectic Substances in Tea Leaf.—Shaw* suggests that pectic substances may be of considerable importance as factors in the quality of tea. Certainly tannins and related substances as determined by precipitation with various reagents, or oxidised and titrated under standard conditions, cannot be related directly to tasters' valuations in every case as mentioned above in the case of leaf from manurial experiments. Caffeine, although an important ally of the tannin class of substances, does not appear to influence quality by its amount.

Considering all the evidence and the interpretations suggested above in the Biochemical Section of this report, it appears sound to take the view that, as a class, tannin substances play the most important rôle in determining quality in tea but that other substances modify the influence of the polyphenols (tannin class) either by their own characteristics or by physico-chemical interaction such as may occur in the colloidal state.

A hypothesis such as the above, even if quite incorrect, will serve as a useful foundation upon which to base further work until such time as a change of policy becomes desirable. We therefore decided to gather some information about the pectic substances of Ceylon teas since it seems quite probable that they may modify the reaction of the polyphenols both during manufacture and in their effect upon the taster's palate.

* U.P.A.S.I. Tea Scientific Department Bulletin No. 6 (1934).

Characters such as stickiness of withered and rolled leaf (often associated with good quality in Ceylon), maltiness of fired tea, and the apple-like odour of well-withered leaf, may quite possibly be associated with pectin content.

In the first place it was decided to concern ourselves only with the total amounts of pectic substances and not to attempt to differentiate between the different forms of these substances present in tea leaf. For this purpose we used the method of Carre and Haines (1922), extracting the total pectic substances by means of ammonia oxalate. There are very few data available on the content of pectic substances in Ceylon teas, so it was decided to keep a record of seasonal changes in young and old leaf with the following results.—

Date of Pluck	Per cent. Pectin (calculated on dry matter)	
	Old tea pruned in Sept., 1934	Young tea pruned in May, 1936
18.1.37 ...	5.74 ...	5.12
30.1.37 ...	5.56 ...	5.12
11.2.37 ...	5.97 ...	6.10
23.2.37 ...	6.10 ...	4.18
6.3.37 ...	5.30 ...	5.35
19.3.37 ...	6.13 ...	4.41
31.3.37 ...	6.75 ...	6.65
12.4.37 ...	6.00 ...	5.83
24.4.37 ...	6.23 ...	6.18
6.5.37 ...	5.55 ...	5.43
18.5.37 ...	6.02 ...	5.90
31.5.37 ...	6.63 ...	6.95
11.6.37 ...	6.73 ...	6.74
23.6.37 ...	7.00 Pruned ...	7.20
	Observations continued on leaf from No. 7 field pruned in July, 1935.	
5.7.37 ...	7.78 ...	6.85
29.7.37 ...	6.87 ...	6.07
10.8.37 ...	7.45 ...	7.65
23.8.37 ...	6.37 ...	7.19
4.9.37 ...	5.32 ...	6.12
16.9.37 ...	6.70 ...	6.14
28.9.37 ...	5.20 ...	5.00
10.10.37 ...	7.25 ...	6.88
3.11.37 ...	4.85 ...	5.22
27.11.37 ...	4.00 ...	5.20

Beyond giving a general idea of the amount of pectic substance present in tea leaf these figures do not give much definite information. The varia-

tions shown are abrupt and not very consistent, and may easily be due to variations in plucking since special care was not taken in selecting samples, these being obtained from ordinary estate leaf as it came to the factory.

It is rather remarkable that, on the average, the figures for dry weather leaf are lower than those obtained during monsoon months which is contrary to expectations since tea leaf is usually appreciably stickier during dry weather than in the wet season.

A few preliminary experiments have been carried out on the effect of withering on pectic substances which tend to show that degree and length of wither do not affect the total amount of pectic substances present in the leaf. Samples of leaf selected from individual bushes for the purpose of the withering experiments suggested that there may be considerable differences between the content of pectic substances in leaf from different bushes.

It is intended to go more fully into these questions during 1938.

GENERAL MANUFACTURE.

Withering.—Withering experiments, as in 1936, were confined mainly to the laboratory. The results shown in the Annual Report for 1936 have been thoroughly substantiated and no specific reason has been discovered for the large variations found in the behaviour of different pieces of flush gathered from an individual bush. We were interested to note that experiments in Java (*Archief voor de Theecultuur*, No. 3, 1937, page 260) indicated exactly similar behaviour in Java leaf.

Rolling.—This particular section of our investigation on manufacture has demanded our attention rather to the exclusion of other sections. The main developments are concerned with the Clivemeare roller which is a somewhat revolutionary departure from the usual form of tea-rolling machine.

The Commission of Enquiry on the Tea Scientific Department of the Indian Tea Association expressed the view in their report that in general the lines of research on tea manufacture tended to be too restricted in their outlook, and advocated an enquiry into entirely new methods as well as investigation of lines of improvement on the existing methods

The Clivemeare roller is the first venture of this Department into what we may term (considering the antiquity of present day methods) unorthodox processes. The C.T.C. machine, which the Clivemeare roller resembles in some respects, was tried out and abandoned in Ceylon before this Department was sufficiently well established to be able to consider exploratory as distinct from investigational lines of work, but now that facilities are available for this type of work we are glad to have had an opportunity to investigate a process which strikes a new line and appears to have a reasonable chance of success.

Whatever may be the fate of the Clivemeare roller, the experience gained has fully justified the time spent on the process, and at the time of writing there appear to be very fair prospects of this roller becoming, under certain conditions, a part of normal factory equipment, with a resultant improvement in some types of Ceylon teas.

Apart from the technical experience these experiments have afforded, it has been most instructive to receive full reports from various tasters who have seen the teas and given their opinion, based on their own requirements, which have been explained in detail. Samples which are out of the ordinary range of teas serve to demonstrate the different requirements of different buyers in a large market such as the London Market.

There is of course nothing approaching the perfect tea which will suit all requirements and, even if there were, every factory in all producing countries obviously could not turn out an exactly similar product. The blenders therefore who carry out the adjustments and compensations required by the bulk of the teas before these become suitable for general consumption appear on this account to form the nucleus of the market.

Clivemeare leaf has, in the course of being sent to a large number of different firms, met with a very varied reception. In some quarters it has not been favoured, but certain London blenders have shown a marked interest in it as an improvement on normal up-country Ceylon tea for blending purposes. It therefore appears that there may be a considerable market for Clivemeare tea, depending in the main on how much blenders can utilise.

We have now reached a stage in our experiments where we are planning the manufacture of an invoice of Clivemeare tea which is to be sold on the London market at the same time as a comparable invoice manufactured in the ordinary way.

It is too early to go into details of the methods employed with this roller, and it is sufficient to say that in general we use a softer wither than usual, the leaf containing approximately 60 per cent. of moisture. The withered leaf is put through the Clivemeare roller first and is then rolled in more or less the usual way. Mr. Clive Meares spent a month at St. Coombs when the machine was first installed during which time the main details of the process were worked out.

Although the machine is quite simple, great care is required with the method, and certain principles must be very closely followed. Any Ceylon estate adopting this type of manufacture will however be able to obtain all the advice and help necessary, from this Department.

Everything at present depends on the outcome of the commercial scale experiments which are being actively planned. These experiments will afford exact information upon out-turn of grades, etc., while the reports of the blenders will give some information on the degree to which they can make use of the various grades.

Some very interesting questions from the chemical and biochemical point of view have been raised by the Clivemeare process. One is apt to explain all improvements in rolling as due to "more thorough expression of juice" which is very vague and is really only a roundabout way of restating the fact that improvements have taken place.

When hard pressure is applied to leaf with the Clivemeare roller there is a most marked increase in colour and strength when compared with identical leaf manufactured on ordinary rollers. If this improvement were due entirely to a greater disruption of the leaf, it would be reasonable to expect that the liquor would contain a greater weight per cup of total solids in the case of the Clivemeare liquor than in the ordinary liquor. If such were the case, there would be a possible disadvantage in the Clivemeare leaf if the extra colour and strength in the first cup was merely a result of most of the soluble material passing into the first brew and so exhausting the leaf that a second brewing would give a very watery liquor. In such a case there would inevitably be complaints from many consumers who want the utmost value for their money.

These considerations were put to the test on seven samples as follows.—

Sample No. 1 was St. Coombs ordinary commercial B.O.P.

,, ,, 2 was a Clivemeare B.O.P., in which the withered leaf was put straight through the Clivemeare machine.

,, ,, 3 was a Clivemeare B.O.P., in which the withered leaf had been rolled once in the ordinary way before putting through the Clivemeare machine.

All these samples were made from the same batch of green leaf.

Sample	% Extract	% Caffeine	% Theotannin	
			Iodine method	Formalin method
No. 1. St. Coombs, B.O.P.	41.0	3.20	21.5	20.5
No. 2 W. L. Clivemeare B.O.P.	38.2	3.08	21.1	20.3
No. 3. R. L. Clivemeare B.O.P.	40.0	3.04	20.6	20.1

The brew in this case aimed at complete extraction of the leaf, which was boiled for 30 minutes.

Sample No. 4 was again a commercial St. Coombs B.O.P.
,, ,, 5 was a corresponding Clivemeare B.O.P.
,, ,, 6 was a Diyanilakelle* B.O.P., which is well-known for its strong and coloury liquoring characters.
,, ,, 7 was made from longer withered Diyanilakelle leaf by the Clivemeare process at St. Coombs.

In this case the teas were brewed for 5 minutes using tasters' cups and scales.

Sample	% water soluble matter extracted successively			Total
	1st Brew (5 mts.)	2nd Brew (5 mts.)	3rd Brew (5 mts.)	
St. Coombs B.O.P. (Factory roller)	25.4	7.7	3.1	36.2
St. Coombs B.O.P. (Clivemeare)	26.1	7.3	2.5	35.9
Diyanilakelle B.O.P. (Factory)	26.3	8.6	3.5	38.4
Diyanilakelle B.O.P. (Clivemeare)	27.4	7.1	2.6	37.1

Perusal of the figures appertaining to these seven samples indicate that the total soluble extract of the Clivemeare leaf is actually less than that of ordinary tea. To a slight extent, the relative amount of solids extracted in the first brew is higher than in the case of ordinary B.O.P. but this was not actually discernible to the eye, the Clivemeare leaf appearing to give the more coloury liquor in each of the three brews. The difference in the first brew was quite remarkable in the case of the short-withered St. Coombs leaf. We cannot therefore explain the action of the Clivemeare roller by the relative amount of soluble substance which it renders available for liquoring. The various substances which contribute towards colour and strength and other tea characters must be present in a better form or state although their total weights are of the usual order.

This is in keeping with Mr. Clive Meare's own explanation which attributes the improvement of liquor and infusion to the short and complete nature of the rolling process which starts fermentation of all liberated substances at the same time. All the "Juice" therefore has the same fermentation both in regard to time and temparature.

The suggestion is, therefore, that the actual mechanism of the improvement is to be sought in the fermentation.

Determination of the enzyme activity of carefully selected and bulked leaf after treatment in ordinary and Clivemeare rollers reveals a much higher activity in the leaf rolled in the Clivemeare roller. In the earlier

* We are indebted to Mr. A. T. Sydney Smith for these facilities.

experiments the residual potentially active enzyme in the fired tea was found to be twice the normal amount, which was consistent with certain difficulties in keeping quality experienced at this stage of the experiments. The fermentation of Clivemeare rolled leaf is markedly quicker than normal as would be expected from the high enzyme activity, and this appears to be at least to some extent responsible for the fine red colour of the infusions.

A great deal of interest was shown in this process during the early stages of the experiments and we are indebted to several gentlemen for assistance rendered in various ways. In a number of cases green or withered leaf was sent to us for manufacture which was very helpful in gauging the general possibilities of the Clivemeare machine. Such co-operation is greatly appreciated by this Department.

Batten Types.—In the report for 1936 some account of various experiments with batten types was given. Continuing these experiments, we graded out the whole charges of leaf and sent all grades to the teams of tasters for valuations. We will adhere to the terms X, Y and Z for the different batten types until such time as experiments have been extended to a commercial scale.

1. **X vs. Z. Equal Pressures and Speeds.**

(Cf. Annual Report 1936, page 75)

TABLE I

PER CENT OUT-TURN OF DHOOLS (Average.)

	Battens	
	Type X	Type Z
Dhool 1	14	7
,, 2	29	16
,, 3	35	20
Bulk	22	57

The large percentage of bulk from type Z shown in Table I calls for comment. The conditions of the experiment demand exactly equal treatment in both cases so this bulk was actually fired and graded. With the small quantities of leaf available the bulk could not be reduced below 20 per cent., and so this was taken as the level to which to reduce the bulk from Type Z by extra rolling in a further *separate* series of experiments. Extra rolling is, of course, the obvious procedure in general practice.

The dhools as given in Table I were graded out with the following results :—

TABLE II

PER CENT OUT-TURN OF GRADES AND VALUATIONS (Average.)

Grade	% Out-turn		Colombo Valuation in cts.		London Valuation in pence	
	Type X	Type Z	Type X	Type Z	Type X	Type Z
B.O.P.	66.7	36.7	87	92	$17\frac{3}{4}$	$17\frac{3}{4}$
F.P.	6.0	5.3	$85\frac{1}{2}$	91	18	$17\frac{3}{4}$
O.P.	3.7	5.6	78	80	$16\frac{1}{8}$	$16\frac{1}{8}$
B.P.	11.3	30.7	77	80	$15\frac{3}{8}$	$15\frac{1}{8}$
Pekoe	6.3	16.7	86	89	17	$16\frac{3}{4}$
Fannings	4.0	3.0	90	91	$17\frac{1}{4}$	$16\frac{7}{8}$
Dust	2.0	2.0	74	74	$16\frac{1}{8}$	$15\frac{3}{8}$
"Sale"* Average			85	$86\frac{1}{2}$	$17\frac{2}{8}$	$16\frac{3}{8}$

* Calculated in the same way as sales averages. ...

In the previous case (Annual Report, 1936, page 75) the B.O.P. was taken from the first three dhools only and was the only grade set for valuation. It is interesting to note that under the condition of the present experiment, the Colombo tasters still show a marked preference for the Type Z *B.O.P.* whereas London tasters do not show any preference and in general prefer type X teas.

2. X vs. Z. Equal Big Bulk Out-turns.

Equal pressures were applied for the first three rolls, but a fourth roll was taken in the case of the type Z batten in order to reduce the big bulk to a quantity similar to that obtained with type X batten.

The average of the valuations given by the tasters for this series of experiments were as follows:—

TABLE III

Grade	Colombo Valuation in cents		London Valuation in pence	
	Type X	Type Z	Type X	Type Z
B.O.P.*	$77\frac{1}{2}$	80	$15\frac{5}{8}$	16
F.P.*	80	81	$15\frac{1}{2}$	$15\frac{3}{4}$

* The B.O.P. and F.P. constituted the greater part of the tea.

In this case both Colombo and London preferred the type Z teas although the preference shown by London amounts to only a fraction of a penny.

The probable explanation of this change is the improvement in liquor of the type Z teas with the extra rolling. It is becoming more and more obvious as these experiments proceed that there is a fundamental difference

between the requirements of the London and Colombo markets. Under the section dealing with the Clivemeare roller mention was made of these differences and actually the Clivemeare leaf was rejected by Colombo tea traders as being unsuitable for their requirements.

The Colombo export trade (as distinct from the shipping activities to the U.K. for the London market) has been slowly and carefully built up over a number of years and has attained considerable importance. Owing, no doubt, to the character of their own trade and the specialised demands of their customers (largely so far as we have ascertained Australian and South African), the Colombo traders on the whole demand a higher standard of appearance of dry leaf than that demanded by the majority of traders in London although no doubt there are dealers in London who specialise in fine showy teas.

The London market, owing possibly to the influence of the big blenders, seems to pay more attention to liquor and less to the appearance of the dry leaf although there are definite limits to their tolerance. The object of this digression is not, as we hasten to point out, to record results of research into the economics or statistics of the tea trade, but to raise a new consideration which must be taken into account in research on tea manufacture. It appears quite possible that results of any particular experiment may only hold good for a particular set of circumstances unless the greatest care is taken in finding the requirements of the various sections of the trade, and ensuring that these requirements are normal and not due to a temporary phase of activity, such for instance as may occur with flavour or tip.

It appears in general that the majority of producers are not very conversant with the varying demands that their teas encounter. Much time and energy must be wasted every year through endeavours to produce characteristics that are not in general demand and in fact most estates work very much in the dark in-so-far-as knowing what is required of them. The variations of demand may defeat any attempts to organise supply, but if we know more about what happens to our products when they leave the factory, much waste of time would be avoided and a good deal of interest stimulated in addition. With this end in view we hope to persuade a number of people who are thoroughly conversant with the ins and outs of the trade both in London and Colombo, or in fact anywhere of general interest, to write a series of articles for *The Tea Quarterly* and furthermore to contribute reports as the situation changes from time to time.

Some apology may appear necessary for this lengthy digression, but it will become apparent as further results are quoted that serious difficulties have been encountered in these differences of opinion, which are of more than experimental importance, being in fact considerations of general application.

Continuing the account of the batten experiments therefore we come to a third method of comparison between batten types X and Z which, of

the three cases, is of the most importance since it conforms to general practice in that pressures were adjusted (at constant speed) to give equal dhool out-turn.

3. **X vs. Z. Equal Dhool Out-turn (Constant Speed).**

Again, in this case, to avoid a multiplicity of samples, B.O.P. and F.P. grades only were sent for valuation, the averaged results being given in the following Table.—

TABLE IV

Grade	Colombo Valuation in cents.		London Valuation in pence.	
	Type X	Type Z	Type X	Type Z
B.O.P.	76	74	$16\frac{1}{2}$	$16\frac{1}{2}$
F.P.	74	$72\frac{1}{2}$	$16\frac{3}{8}$	$16\frac{3}{8}$

Again we find the difference of opinion, each team of tasters being agreed amongst themselves and differing as two units.

This time however we find a reversal of the order of preference by the Colombo tasters.

Equal dhool out-turns involve heavy pressure in the case of type Z battens as against relatively light pressure with type X battens, since as previously described, the dhool out-turn of type X is almost twice that of type Z under equal conditions of pressure and speed.

Further experiments on this point were therefore carried out, two rollers having the same batten type being used, in one case with very hard pressure, and in the other case with very light pressure.

4. **Hard Pressure on X vs. Light Pressure on X.**

The mesh on the roll breakers was so arranged that approximately equal amounts of dhool were taken from each roller. Several experiments were carried out, all grades being sent for valuation. The averaged results are given in Table V.—

TABLE V

Grade	% Out-turn		Colombo Valuation in cents		London Valuation in pence	
	L. Press.	H. Press.	L. Press.	H. Press.	L. Press.	H. Press.
B.O.P.	45.2	49.6	76	74	$16\frac{3}{4}$	$16\frac{3}{8}$
F.P.	14.0	2.5	75	$72\frac{1}{2}$	$16\frac{3}{4}$	$16\frac{1}{4}$
O.P.	5.7	5.5	75	73	$15\frac{3}{4}$	$15\frac{3}{8}$
B.P.	18.6	26.1	72	72	$15\frac{3}{8}$	$15\frac{1}{4}$
Pekoe	8.8	4.0	$72\frac{1}{2}$	71	16	$15\frac{3}{4}$
Fannings	5.8	9.2	74	72	$16\frac{3}{8}$	$16\frac{1}{8}$
Dust	1.9	3.1	69	69	$15\frac{1}{8}$	$15\frac{1}{8}$
		Average :—	$74\frac{1}{2}$	73	$16\frac{3}{8}$	16

The application of hard pressure to a batten does not therefore obtain the best results.

The foregoing is intended as a progress report and not to convey any hard-and-fast conclusions regarding batten types. Progress has been slow and in many ways disappointing, but sufficient has been done to reveal further complications of what, at first, may appear a simple matter. It is evident therefore that commercial scale experiments cannot be embarked upon for some time to come.

Further investigation of the effects of pressure upon batten performance in relation to quality (using the word quality in the broadcast sense) is evidently necessary.

The majority of the experiments were carried out in monsoon months and in view of possible seasonal variations in both leaf and markets it is desirable that conclusions should be tested at all seasons.

Once the main points have been elucidated it is most probable that systematic manufacture will have to be carried on for a year or so (on the same lines as field experiments) to get a final answer to problems of batten type.

Firing.—The amount of work undertaken in other sections handicapped the programme of firing experiments envisaged for 1937.

The new experimental dryer which was designed entirely for experimental work has proved, on the whole, to be very satisfactory but in one particular respect a great deal of trouble has been experienced, namely in the distribution of the air flow. The aim has been to get a high degree of perfection in the air distribution and this has entailed a long and tedious series of trials with baffles and deflectors.

We have eventually arrived at a very satisfory solution which entailed the construction of a plenum chamber between the heater and the trays, the air being discharged from this chamber through a series of tubes distributed evenly over a circular baffle in the main duct. The length of each tube is three times its own diameter and will fill with air when a static pressure of roughly 0.5 inch water gauge is maintained in the plenum chamber.

Grading.—The results of tests with Stamped Aluminium Sheets were reported in *The Tea Quarterly*, December, 1937. Aluminium sheets with circular perforations may become available in 1938, in which case they will be subjected to similar tests.

Packing.—A large number of materials of considerable promise as packing materials were tested during 1937. In the case of Kraft Paper our experiments reached the commercial stage and every satisfaction was expressed on the condition of Kraft Paper-lined packages on arrival in London. Kraft Paper became available for general use and was adopted by a number of estates as an alternative to lead or aluminium,

The moisture proof qualities and the strength and the ease of sealing of Kraft Paper all contributed towards making what appeared to be an ideal lining, a solution to the complaints about the flimsy nature of chest linings, the tears and perforations sustained in transit, and the consequent apparent liability to deterioration of teas in transit.

These qualities of Kraft Paper are, however, of less importance, or so it seems, than the cash value of the chest lining as scrap metal, which consideration has superseded all others with the result that buyers have given instructions to their representatives not to buy Kraft Paper-lined packages.

It should be pointed out however that, owing to the rise in the price of paper which took place during the year, Kraft Paper became slightly more expensive than the normal gauge of aluminium and so *if* the buyers are quite satisfied with ordinary aluminium foil, there is little incentive to adopt more expensive linings which are liable to meet with objections from their customers.

If the buyers are satisfied with the present form of packing in thin aluminium foil, then any further investigations must be directed along lines of finding methods equally satisfactory to the buyer but less expensive to the producer.

Experiments have been carried out with Cellophane and Pliofilm. There are several grades of both these materials and a certain number of each are moisture proof and surprisingly strong.

Tough paper rendered moisture proof by a coating of moisture proof plastic material like Cellophane or Pliofilm is another promising line of research.

A considerable amount of work has been done on this subject and it is hoped that some material benefit to the industry will eventually result from it.

The following is a brief summary of the tests undertaken during 1937 :—

1. **Kraft Paper Class.**

Kraft Paper. Three experimental shipments to London. Also laboratory and factory tests. Several invoices of St. Coombs commercial teas were packed in Kraft Paper.

White paper-backed aluminium laboratory and factory tests.
White paper-backed aluminium with Bitumen adhesive ,, ,, ,, ,,
Waxed paper-backed foil "Aluminite" ,, ,, ,, ,,

2. **Pliofilm** Numerous laboratory and factory tests.
Thick grade. 1 experimental shipment.
Thin grade. 1 experimental shipment,

3. **"Plioglaze"** A coated paper. Laboratory and factory tests.

4. **Cellophane** Grade M.S.T. 400. Numerous laboratory and factory tests. 1 experimental shipment.

We have to acknowledge our indebtedness to Messrs. Thomson, Alston & Co. Ltd., who undertook to receive and examine the experimental shipments on arrival in London. Also to Messrs. Whittall & Co., Mr. James Forbes (Jnr.), and Mr. C. M. Penny for facilities at this end. The Agents for the various materials tested gave their ready co-operation throughout the tests.

Effect of Moisture Absorption.—In view of the amount of work done on packing materials it was decided to commence an investigation of the limits to which the moisture content of the tea may rise without detriment to quality.

A sample of well bulked B.O.P. was taken and divided into five parts. One part was stored in an airtight, moisture-proof bottle and its moisture content remained at 3.5 per cent. The other four parts were exposed to damp until the moisture content rose to 9.5 per cent. One of these parts was allowed to remain at 9.5 per cent. moisture content for one week after which it was reduced by means of dry air at room temperature to a moisture content of 3 per cent. The other parts were allowed to remain damp for two weeks and one month respectively whilst the fifth was not reduced at all. These samples were then sent to a team of tasters who valued them as follows:—

Sample	Original moisture content %	Moisture content after exposure %	Period at high moisture content Weeks.	Moisture content after redrying %	Valuation Cents
1	3.5	not exposed	—	—	84
2	3.5	9.5	1	3	81
3	3.5	9.5	2	4	79
4	3.5	9.5	4	3	78
5	3.5	9.5	6	not reduced	76 soft

These experiments will be extended in order to discover the safe limit for moisture content.

The preliminary experiment demonstrates a marked deterioration in value when the moisture content rises as high as 10 per cent which is not an improbable figure for the moisture content to rise to under some conditions (Vide *Tea Quarterly*, December, 1935, page 171).

Rapid Determination of Moisture Contents.—The apparatus demonstrated at the last Conference was sent to England to be copied with a view to production. After a very long and unexplained delay a model was sent

out which proved to be unsuitable. The fault, which was traced down, was found to be due to the heating coil which was too small. The error arose through a thermometer, designed to register the temperature of the air flow, having been placed so that it absorbed radiant heat and gave a highly erroneous reading.

MANUFACTURE OF LEAF FROM FIELD EXPERIMENTS.

Cultivation Experiment.—(In conjuction with Agricultural Chemistry Department). Six manufactures of leaf from these experimental plots were carried out in connection with the investigation of the effect of cultivation on quality.

Pruning Experiment.— (In conjunction with Plant Physiology Department). Nine manufactures of leaf from these plots were carried out in connection with the effect of season of pruning on quality.

Spraying Experiment.—(In conjuction with Entomological Department). One manufacture was carried out to determine whether a certain spray treatment caused a taint on leaf from treated bushes. One manufacture was carried out on leaf from the same bushes to determine whether the taint previously observed had disappeared.

Manufacture of Leaf from Individual Bushes.—Advantage was taken of the availability of the Clivemeare roller, which is easily adaptable for the manufacture of small quantities of leaf, to investigate the possibilities of manufacture of leaf from individual bushes. The plant improvement work of the Plant Physiology Department will before long necessitate the selection of bushes for quality and it is by no means too early to consider appropriate methods. Fairly consistent results have been obtained and this particular method of approach to the problem holds considerable promise.

Tasting of Experimental Teas.—The Plant Physiologist carried out certain statistical analyses on the results of the various systems of valuation of teas manufactured by this Department. Some account of these analyses appear in the report of the Plant Physiologist, and it is hoped shortly to publish a joint paper on this subject in a scientific journal.

ACKNOWLEDGMENTS.

Acknowledgments have already been made in different sections of this report and it is sincerely hoped that there are not any omissions. Help and advice has been freely given by all sections of the Industry and we wish to record our appreciation of these fortunate circumstances.

In connection with the tasting of our experimental teas it is a great pleasure to acknowledge the keen and able assistance rendered us by the following firms;—

Messrs. Forbes & Walker, Messrs. Wilson, Smithett & Co., Ltd., Messrs. Geo. White & Co., Messrs. Harrisons & Crossfield, Ltd., Messrs. Whittall & Co., Messrs. The Colombo Commercial Co. Ltd., Messrs. Carson & Co. Ltd., Messrs. Brooke Bond (Ceylon) Ltd., Messrs. Heath & Co., Messrs. Lipton Ltd., Messrs. Sommerville & Co., Messrs. George Steuart & Co., Messrs. E. John & Co., Messrs. Leechman & Co., Messrs. J. Lyons & Co., Messrs. W. J. & Henry Thompson and Messrs. Sanderson & Co.

We are much indebted to Mr. R. H. Horne and Mr. E. B. Loudon-Shand for organising the meetings of tasters in Colombo and London respectively, also to Mr. L. C. A. Leefe who arranged the meetings when Mr. Horne was on leave.

Mr. F. J. Whitehead has continued to render valuable service to this Department for which I personally wish to record appreciation.

J. LAMB.

Tea Technologist.

REPORT

OF

THE SMALL-HOLDINGS OFFICER,

GAMPOLA, FOR 1937.

The work done during the period under review has been more or less centered in one area, namely Yati Nuwera, where we have been able to organise another competition amongst the small-holders in tea. This has been made possible by the ready co-operation of the three Village Committees, who have very generously voted the necessary funds for prizes.

Competitions of this nature are, I find, a great incentive for work. There have been entries from practically every village in Yati Nuwera, thus spreading the work throughout the Division.

The competition itself is spread over a period of 12 months, enabling each and every competitor to carry out the necessary improvements according to instructions. The final judging of the above competition, which is done by an officer of the Institute, takes place in March.

Visits have been made to every competitor's holding in the different villages and advice given as to how best each holding could be improved. The methods generally advocated for the improvement of small-holdings are the adoption of the "Reverse Slope Drains" — "Rim-Lung Pruning" and the planting of green manures. Demonstrations in draining and pruning have been carried out wherever possible on these inspections. Special attention has been paid to pruning, which is more or less carried out under my personal supervision.

Those small-holders who have adopted the "Reverse Slope" drain have found this method better than any other, as the adoption and maintenance of it is cheaper and they take readily to it.

The pruning of tea is still the job of a selected few, and it is not every small-holder who knows how to prune his tea. This makes my task difficult, as the final word on pruning rests with the few selected pruners in each village. Thus the owner of a small-holding is left entirely at the mercy of these pruners, who insist on adopting their methods. Those small-holders who have their holdings close to estates employ Tamil labour, who are considered superior to village pruners. This labour is expensive and it is not all that can afford it.

This does not mean that the village pruner does not know his job. He is inclined, however, to take advantage of the fact that the owner does not know very much about pruning and, with his experience as a pruner in the village, he thinks his work should not be criticised. The pruning on a majority of small-holdings is done on contract, which leads to careless work with little or no supervision. Lastly, careless and bad work on the part of village pruners is in a large measure due to their being underpaid. It is because of these reasons that personal supervision is necessary.

If small-holders would realise the importance of pruning, and that all the crop they expect to harvest depended on the way the tea was pruned, they would pay more attention and improve their methods of pruning.

Today we find small-holders taking very readily to green manures. They have realised the usefulness of growing them and that they have helped to improve the tea. This in a great measure is due to the good example set by the estates, which grow various green manures.

Bought Leaf and Bought Leaf Factories.—Bought leaf factories which were lying idle during the last four years have had a better time and continued to work right throughout the year, thus finding employment for a large number of Sinhalese labourers.

The opening of these factories not only found employment for Sinhalese labour, but they also helped to bring the small-holders an additional income. They have been able to sell their uncouponed leaf at an average price of 2½ cts. throughout the year.

Weather conditions have been normal and this in a great measure helped progress in all directions.

Tea Restriction.—Small-holders have had their final issue of tea coupons for the last year of restriction and these have also been sold.

Tea coupons have been readily disposed of as it is more profitable to do so rather than sell them with their leaf. This will continue to be so until it becomes more profitable to have green leaf sold with coupons.

Restriction has brought prosperity to small-holders. They have had a steady income from coupons. The tea on all holdings has improved by the forced rest brought about by the unsaleability of leaf without coupons. They have had more money to spend on their holdings and improve them. Financially they are in a better position today than they were five years ago.

Restriction is to be extended over another period of five years, and I expect small-holders to continue maintaining and improving their holdings.

General.—Dr. Grasvosky and Mr. Lester-Smith were shown round some small-holdings worked directly under my supervision.

Groups of Agricultural Instructors were shown round some of the small-holdings, where the improved methods of cultivation had been adopted, on three occasions during the year.

Four Agricultural and Co-operative Propaganda Meetings were attended during the year.

A special visit was made to Balangoda at the request of the Ratnapura District Agricultural Committee and a week was spent among the small-holders in this area. The week's work was begun with a meeting of small-holders of the district, kindly arranged by the Ratemahatmaya. I spoke to them on the improved methods of cultivation and the importance of working their holdings systematically. This was followed up by visits to different villages and demonstrations were carried out on various holdings in draining and pruning, and advice given as to how best the respective holdings could be improved.

These competitions have helped progress considerably in the three Divisions (Udu Nuwara, Uda Palata, Yati Nuwara) and today we are able to find demonstration blocks in practically every village.

If present conditions prevail I expect increased progress, when small-holders will adopt more improved methods of cultivation in the working of their holdings.

R. L. ILLANKOON,

Small-Holdings Officer.

METEOROLOGICAL OBSERVATIONS, 1937.

ST. COOMBS.

Month	Temperature				Mean Relative Humidity	Rainfall Inches	No. of Rainy days	Sunshine
	Mean Max.	Mean Min.	Adopted Mean.	Mean on Grass				hrs. mts.
January	74·2	55·7	65·0	49·4	74	3·96	14	189 54
February	76·9	55·8	66·4	49·0	70	3·08	9	223 40
March	79·0	54·6	66·8	48·8	64	3·93	10	256 05
April	78·1	58·7	68·4	54·8	78	4·87	18	188 31
May	76·8	60·6	68·7	57·7	82	6·56	18	178 00
June	72·0	60·4	66·2	58·8	85	7·55	25	108 42
July	70·3	60·1	65·2	59·3	88	16·68	27	88 58
August	73·9	59·2	66·6	56·5	83	9·75	19	145 14
September	75·5	56·1	65·8	52·7	77	7·36	12	183 52
October	75·1	56·8	66·0	51·9	79	9·12	19	211 44
November	74·2	58.9	66·6	54·6	82	9·02	25	107 62
December	74·1	52·8	63·4	44·3	71	3·54	13	227 27
Annual	75·0	57·5	66·2	53·2	78	85·42	209	2109 59
			Means				Total	

THE TEA RESEARCH INSTITUTE OF CEYLON.

BALANCE SHEET AS AT 31st DECEMBER, 1937.

LIABILITIES

	Rs. Cts.	Rs. Cts.
CREDITORS & CREDIT BALANCES :—		
Accrued Interest on Loan ...	10,834·53	
Small-Holdings Suspense Account	150·00	
Sundry Creditors—Research ...	6,581·01	
Sundry Creditors—Estate ...	9,040·97	
Motor Road Roller ...	501·96	27,108·47
FURLOUGH RESERVE :—		
At 31st December, 1936 ...	9,784·94	
Add : Reserved during 1937 ...	7,003·00	
	16,787·94	
Deduct : Payments during 1937 ...	1,079·15	15,708·79
DEPRECIATION RESERVE :—		
At 31st December, 1936 ...	243,296·62	
Credited at 31st December, 1937 ...	38,618·79	281,915·41
Carried forward		Rs. 324,732·67

ASSETS

		Rs. Cts.	Rs. Cts.
DEBTORS & DEBIT BALANCES :—			
Controller of Finance & Supply ...		21,401·43	
Lindoola Estate, Share of Upkeep of Mattakelle Cart Road ...		250·00	
Superintendent St. Coombs Assessment of Acreage Fees ...		9·25	21,660·68
SUNDRIES RESEARCH :—			
Ceylon Association in London ...		456·36	
Research Staff ...		1,467·55	
Sundry Debtors A/c. Advertising		1,158·00	
Accrued Interest on Fixed Deposits		743·32	
		3,825·23	
SUNDRIES: ESTATE		651·55	4,476·78
STOCK-IN-HAND :—			
Tea 18,661 lbs.		14,483·02	
Estate Rice	1,064·05		
do Stock	1,688·41	2,752·46	17,235·48
INVESTMENTS :—			
£ 2,300-0-0, 3½ % War Loan			32,434·76
Rs. 30,000, 3½ % Ceylon Govt. Loan			29,512·50
Carried forward			Rs. 105,320·20

THE TEA RESEARCH INSTITUTE OF CEYLON.

BALANCE SHEET AS AT 31st DECEMBER, 1937.—(*Contd.*)

LIABILITIES		ASSETS			
			Rs. Cts.	Rs. Cts.	
Brought forward	Rs. 324,732·67	Brought forward		105,320 20	
		CASH :—			
		Research Fixed Deposit ...	61,140·97		
		,, Current Account ...	36,654·12		
		,, In Hand ...	91·80		
			97,886·89		
		Estate—N. B. I. Colombo 6,095·58			
		,, In Hand 123·96	6,219·54	104,106·43	
		FUNDS OVERSPENT :—			
		At 31st December, 1936 ...	85,582·49		
		Capital Expenditure 1937 ...	46,484·70		
		Repayment of Loan 1937 ...	30,310·53		
			162,377·72		
		Less : Revenue applied for capital purposes, being revenue account surplus for the year	47,071·68	115,306·04	
	Rs. 324,732·67			Rs. 324,732·67	

We have audited the books of the Tea Research Institute of Ceylon for the year ended 31st December, 1937.

The allocations of Capital Expenditure and of Research Revenue Expenditure as made by the Director and sanctioned by the Chairman have been accepted by us.

We are not in a position to say whether the Reserves made for Depreciation are adequate.

Subject to the foregoing reservation, we certify that, to the best of our belief, the above Balance Sheet presents a true and correct view of the financial affairs of the Institute at 31st December, 1937 according to the information and explanations given to us and as shown by the books.

(Sgd.) FORD, RHODES, THORNTON & Co.,
Chartered Accountants.

Colombo, 17th March, 1938.

THE TEA RESEARCH INSTITUTE OF CEYLON.

Dr. **CAPITAL ACCOUNT AS AT 31st DECEMBER, 1937.** **Cr.**

EXPENDITURE

	To 31-12-36 Rs. Cts.	Additions 1937 Rs. Cts.	Transferred from Revenue Account Rs. Cts.	Deduct cost of Assets sold or scrapped etc. in 1937 Rs. Cts.	Total Rs. Cts.
To Land Including Development	797,044·14	13,476·47	—	—	810,520·61
,, Buildings and Lines	856,354·03	17,168·13	—	—	873,522·16
,, Furniture and Equipment	74,792·05	2,378·27	1,200·80	262·90	78,108·22
,, Laboratory Equipment	37,417·43	1,746·52	—	411·79	38,752·16
,, Experimental Machinery	25,271·54	419·85	—	—	25,691·39
,, Machinery Estate	112,340·63	11,980·15	—	—	124,320·78
,, Motor Car	4,335·00	4,325·00	—	4,335·00	4,325·00
,, Motor Road Roller	7,386·03	—	—	—	7,386·03
Rs.	1,914,940·85	51,494·39	1,200·80	5,009·69	1,962,626·35

RECEIPTS

		Rs. Cts.	Rs. Cts.
By Government of Ceylon:- Loan on Mortgage at 5½ % per annum		1,000,000·00	
Less: Repayments to 31st December 1936	181,723·74		
Payment 1937	30,310·53	212,034·27	£ 787,965·73
,, Revenue Applied to Capital Purposes to 31-12 36		1,011,082·10	
do to 31-12-37		47,071·68	
Transfer between Capital and Revenue		1,200·80	1,059,354·58
,, Funds Overspent to 31-12-36		85,582·49	
During 1937		29,723·55	115,306·04
			Rs. 1,962,626·35

THE TEA RESEARCH INSTITUTE OF CEYLON.

ESTATE WORKING ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1937.

EXPENDITURE		Rs. Cts.	INCOME			Rs. Cts.
To Estate Revenue Expenditure	...	89,383·74	By Tea Sales—Local	170,099 lbs.		139,524·95
,, Charges—Export Duty, Etc.	...	8,037·23	,, Do —Factory	641	,,	477·94
,, Balance Carried Forward	...	42,919·87	,, Do —Broken Mixed	2,081	,,	312·15
			,, Do —Clivemeare Tea	129	,,	25·80
	Rs.	140,340·84			Rs.	140,340·84

REVENUE ACCOUNT AS AT 31st DECEMBER, 1937.

Dr. **Cr.**

	Rs. Cts.	Rs. Cts.		Rs. Cts.
To Administration of the Board:—			By Balance from Estate Working Account	42,919·87
Planters' Association of Ceylon	240·00		,, Tea Cess	298,686·52
Travelling of the Board ...	2,599·75		,, Rent of Caddy	60·00
Clerical Staff ...	5,779·20		,, Interest Account	3,004·75
Telephone Operators ...	912·00		,, Miscellaneous Receipts	41·00
Office Peon ...	564·00			
Postages ...	563·65			
Stationery ...	1,375·05			
Advertising ...	—			
Telegrams, Trunk Calls etc. ...	180·26			
Printing ...	205·85			
Legal Expenses ...	—			
Auditors' Fees and Expenses	713·09			
Contingencies ...	122·60	13,255·45		
Carried forward	Rs.	13,255·45	Carried forward	Rs. 344,712·14

Dr. **REVENUE ACCOUNT AS AT 31st DECEMBER, 1937.**—*(Contd.)* **Cr.**

			Rs. Cts.		Rs. Cts
	Brought forward		13,255·45	Brought forward	344,712·14
To Personal Emoluments of Scientific Staff :—					
Director	...	22,500·00			
Mycologist	...	20,476·56			
Agricultural Chemist	...	15,910·29			
Tea Technologist	...	10,846·57			
Entomologist	...	16,237·10			
Plant Physiologist	...	13,820·86	99,791·38		
,, Emoluments of Junior & Sub. Scientific Staff :—					
Junior Scientific Staff	...	28,367·02			
Lab. Attendants and Fieldmen		4,058·60	32,425·62		
,, Laboratory :—					
Equipment and General Working Expenses	...	4,816,53			
Furniture	...	91,95	4,908·48		
,, Library and Publications :—					
Library	...	1,923·14			
Publications	... Cr.	1,487·77	435·37		
,, Small-Holdings :—					
Salaries and House Allowances		6,573·00			
Travelling and General Expenditure		3,098·37	9,671·37		
,, Field and Factory Experiments :-					
Agricultural Chemist	...	3,032·79			
Plant Physiologist	...	3,845·24			
Factory Experiments	...	1,635·88	8,513·91		
	Carried forward	Rs.	169,001·58	Carried forward	Rs. 344,712·14

Dr. **REVENUE ACCOUNT AS AT 31ST DECEMBER, 1937.**—*(Contd.)* **Cr.**

	Rs. Cts.	Rs. Cts.		
Brought forward		169,001·58	Brought forward	Rs. 344,712·14
To Travelling of Staff:—				
Officers' Expenses ...	3,475·96			
Insurance of Car and Taxes ...	182·83			
Drivers' Wages ...	1,202·74			
Drivers' Batta ...	379·00			
Running Expenses ...	3,528·58			
Entertainment Allowance ...	871·90	9,641·01		
,, Maintenance of Buildings:—				
Laboratory ...	464·67			
Six Senior Staff Bungalows ...	940·17			
Eleven Junior Staff ,, ...	791·97			
Clerks Bungalows ...	156·05			
Miscellaneous Lines & Buildings	347·49	2,700·35		
,, General Services:—				
Electric Power ...	3,816·02			
Engine Room Staff ...	177·47			
Mechanic ...	840·00			
Telephone Rent & Maintenance	568·50			
Roads ...	1,627·88			
Sanitation ...	847·44			
Water Supply ...	870·60			
Tappal, Lorry & Book Fees ...	234.00			
Nettikans & Drains ...	—	8,981·91		
,, Upkeep of Grounds:—				
Labour and General Expenses	459·00			
Tennis Court ...	385·43	844·43		
Carried forward	Rs.	191,169·28	Carried forward	Rs. 344,712·14

THE TEA RESEARCH INSTITUTE OF CEYLON.

Dr. **REVENUE ACCOUNT AS AT 31ST DECEMBER, 1937.**—*(Contd.)* **Dr**

	Rs. Cts.	Rs. Cts.
Brought forward		191,169·28
To Miscellaneous :—		
Incidentals ...	140·01	
Provident Fund Senior Scientific Staff	9,971·93	
Provident Fund Junior Scientific Staff	3,489·39	
Provident Fund Clerical and Sub. Staff	1,331·16	
Passages ...	3,750·00	
Ceylon Nursing Association and Fraser Nursing Home ...	180·00	
Medical Fees Sub. Staff ...	190·25	
Medical Scheme Junior Staff	1,056·50	
Insurances ...	2,075·56	
Watchmen and Caretakers ...	488·31	
Conference Expenses ...	350·92	
Rentals ...	240 00	23,234·03
,, Government of Ceylon Loan Interest Account		44,588·36
,, Depreciation Account ...		38,618·79
,, Balance ...		47,071·68
	Rs.	344,712·14

	Rs. Cts.
Brought forward	Rs. 344,712·14
	Rs. 344,712·14

Dr. **LOAN ACCOUNT.** **Cr.**

		Rs. Cts.		Rs. Cts.
To Government of Ceylon ...	Rs.	1,000,000·00	By Repayments Principal :—	
			1st Instalment 1929 ...	18,227·00
			2nd do 1930 ...	19,320·72
			3rd do 1931 ...	20,479·00
			4th do 1932 ...	21,708·60
			5th do 1933 ...	23,011·09
			6th do 1934 ...	24,391·74
			7th do 1935 ...	25,855·23
			8th do 1936 ...	28,730·36
			9th do 1937 ...	30,310·53 212,034·27
			Balance ...	787,965·73
	Rs.	1,000,000·00		Rs. 1,000,000·00

The Tea Research Institute of Ceylon.

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Field Assistants	...	F. H. Kehl
	...	F. P. Jayawardana
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	...	E. F. Kannangara

Superintendent, St. Coombs Estate ... J. A. Rogers

NOTE.

The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

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